Hydrologic Assessment
of the Gazos Creek Watershed
San Mateo and Santa Cruz Counties, California

Prepared for:

Coastal Watershed Council

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Balance Project Assignment 200022

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TABLE OF CONTENTS

Tables

Figures

Appendices

HYDROLOGIC ASSESSMENT SUMMARY

Very little previous work has been conducted to describe and document the hydrologic characteristics of Gazos Creek; that work which has been completed consists of point measurements of streamflow at various locations in the watershed from 1971 through 1993 and basic water quality monitoring during 1998. Since this work was completed and starting in 2000, Gazos Creek has been the focus of a multi-disciplined watershed assessment whose primary focus has been to provide a long-term plan to enhance conditions in the watershed for both coho[1] salmon *(Oncorhynchus kisutch*) and steelhead[2] trout (*Oncorhynchus mykiss*). As a part of this multi-disciplined assessment, a hydrologic assessment has been conducted in an attempt to fill-in existing data gaps and to address the following four critical hydrologic questions:

1. *What are rates and the sources of low flows in Gazos Creek*
2. *What is the basic quality of surface water, particularly at lowest flows?*
3. *What are the dominant discharges, or channel-forming flows?*
4. *What are the very large peak flows of the past 50 years?*

To answer these critical questions, Balance Hydrologics staff (1) installed and operated two temporary gaging stations[3] which continuously recorded water level[4], water temperature and specific conductance, (2) worked with Coastal Watershed Council staff and volunteers to collect streamflow and basic water quality data at seven additional locations in the watershed and (3) level-surveyed a cross section through the GCDFG gaging station where high water marks from 1982, 1998, 2000, 2001 and 2002 were preserved in the floodplain.

Rates of low flows in Gazos Creek are high when compared to other regional streams of similar drainage area and roughly similar watershed average mean annual precipitation; low flows in Gazos Creek during water years 2001 and 2002 ranged from 2 to 30 times

[1] Coho salmon are federally listed as a threatened species and state listed as endangered.
[2] Steelhead trout are federally listed as a threatened species.
[3] The upstream gage was operational from June 19th to November 16th of 2001 and was referred to as the GCCR gage while the downstream gage has been operational since October 2nd, 2001 and is referred to as the GCDFG gage.
[4] Through field observations of streamflow and water level, the continuous records of water level for both gaging stations was used to calculate streamflow at fifteen minute intervals over the periods of operation

greater than corresponding flows in Corte Madera and San Geronimo Creeks. Regionally, water years 2001 and 2002 were characterized as average to slightly below average years for rainfall totals. The magnitude of low flows originating from each of the three upper watershed tributaries is unclear at this time due to a limited dataset. The data that was collected, however, indicates that the magnitudes of flows from each tributary can be dynamic at possibly the daily level. Basic water quality parameters of Gazos Creek were found to be appropriate for salmonids during 2001 and 2002. At the two gaging stations, summertime daily average water temperatures ranged from 9 to 18 degrees Celsius while daily average specific conductance ranged from 240 to roughly 410 µmhos per centimeter (at 25 degrees Celsius). The daily maximum water temperature recorded at the GCDFG gage in water year 2002 was 19.1 degrees Celsius.

The channel-forming flow or bankfull flow was calculated at the GCDFG gage as 840 cfs; the calculation was based on the peak water level recorded during water 2002- a year which resulted in bankfull flow on many regional streams. Additionally, the high water level from 2002 occurred at the first distinct break in slope on the channel bank-a break which was interpreted in the field as being the morphologic bankfull surface. Peak flows from high water levels for water years 1982 and 1998 were calculated to be 4,280 and 2,970 cfs, respectively. Five miles north of Gazos Creek in the Pescadero basin, water year1998 resulted in the peak flow of record at the USGS gaging station followed by water years 1956 and 1982. It is unclear how water year 1956 compares to 1982 or 1998 in the Gazos Creek watershed due to a lack of preserved high water marks and first hand accounts of flood levels.

H. HYDROLOGIC ASSESSMENT

H.1 Background

H.1.1 Hydrologic Assessment Objectives

The primary objective of the hydrologic assessment was to identify existing hydrologic characteristics or restoration opportunities which currently or could in the future have a positive impact to coho salmon (*Oncorhynchus kisutch*) or steelhead trout (*Oncorhynchus mykiss*) habitat in Gazos Creek. To address this objective, Balance Hydrologics (Balance) designed the hydrologic assessment with four key questions in mind:

1. What are rates and the sources of low flows in Gazos Creek? How do the flows compare to those in other Santa Cruz Mountains streams? How much more slowly do they recede both seasonally and during dry sequences of years? How much less salty are they? How much cooler?

2. What are the very large peak flows? How do these compare to those in other streams in the region? How large were the 1998 and 2000 peak flows, both as recurrences and relative to peaks in other streams?

3. What is the quality of the water, particularly at lowest flows?

4. What are the dominant discharges, or channel-forming flows?

H.1.2 Historic watershed hydrologic data

Historic streamflow data for Gazos Creek is limited to spot measurements conducted largely by California Department of Fish and Game (CDFG) staff for several periods starting in 1971 and extending through 1993. These historic data were compiled and catalogued into three distinct data sources by Balance Hydrologics staff (Entrix and Balance Hydrologics, 1998: pages 1-6 through 1-9). The cataloged data is illustrated in **Appendix H-A** of this report. The first source (**Table H-A-1**) of streamflow data was collected from 1971 through 1986 with measurements made at several different locations along the mainstem of Gazos Creek. The second source (**Table H-A-2**) of data was collected in 1978 downstream of the existing diversion (**Figure H-1**) near the mouth from

January to September. The third source (**Table H-A-3)** of data was collected in 1993 at two different locations, one on the mainstem just upstream of Old Woman Creek and the second below the existing diversion.

Table H-A-1 of Appendix A illustrates spot measurements made from 1971 to 1986 during the months of April through November. Discharge values illustrated in **Table H-A-1** for these months basically highlight recessional and baseflow characteristics of Gazos Creek in 1976 and 1986[5]. It is interesting to note that the measurement of 0.34 cfs made on August 10, 1976 illustrates that baseflow was sustained in Gazos Creek during 'extreme' drought conditions.

Tables H-A-2 and H-A-3 of Appendix H-A illustrate spot measurements of streamflow made during water year 1978 and 1993, respectively by CDFG staff. Both years of data illustrate early summer streamflow recession that is typical of Santa Cruz Mountain streams, however late summer flows seem to be on average more persistent than other regional streams (Entrix, 1998). The measurements made in 1993 indicate no apparent trend in flow "gain" or "loss" from Old Woman Creek downstream to the existing diversion during periods when the diversion appears to not have been operating in that year (**Figure H-1)**. The reach was measured to be "gaining" on some days and "losing" on others. In some regional streams it is not uncommon for the lower reaches of streams to be "losing" reaches during summer months due to cumulative impacts from water resource harvesting and bed sedimentation.

Entrix and Balance Hydrologics (1998) also reported that Gazos Creek water quality parameters such as water temperature and dissolved oxygen are not likely limiting to the success of salmonid incubation and rearing under "normal" conditions. In 1998, Coastal Watershed Council (CWC, 1998) reported a range of water temperatures between January and March of 9 and 14 degrees Celsius in Gazos Creek; during the same period they reported dissolved oxygen levels in the range of 8 to 11 milligrams per liter. Entrix and Balance Hydrologics also report that turbidity levels were expected to be high during storm events, however measurements made <u>between</u> winter storms indicated that turbidity did not constrain habitat values during water year 1998.

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[5] Two measurements were conducted in 1976 while four were conducted in 1986. Measurements were also conducted in 1971, 1978, 1979 and 1980, however only one measurement was conducted in each of these years.

H.1.3 Project related hydrologic data

H.1.3.1 Gazos Creek at Cloverdale Road: temporary gaging station

A temporary stream gage including a datalogger and staff plate was installed roughly 200 feet upstream of the confluence with Old Woman Creek (**Figure H-1**) on June 19, 2001. The gage was operated from the installation date to November 16, 2001 to capture baseflow characteristics for 2001 in Gazos Creek. The temporary gage was called Gazos Creek at Cloverdale Road (GCCR), conforming to CWC nomenclature. The watershed at this location has a drainage area of roughly 8.0 square miles. Pertinent information collected at the gage included water level (stage), water temperature and specific conductance[6]. These three parameters were recorded at 15-minute intervals to a datalogger over the period of gage operation. To calibrate electronic measurements and in order to calculate a record of streamflow at the gage for the period, manual measurements of streamflow, stream stage, water temperature and specific conductance were conducted at intervals of about once every 2 weeks. The procedures used by Balance staff to calculate a record of stage and streamflow for the temporary gage are discussed in **Appendix H-B** of this report. Manual measurements of streamflow were made just downstream of the staff plate with these measurements reported in **Table H-1**, under the GCCR station heading.

H.1.3.2 Gazos Creek-DFG telemetered gage

As part of a pilot project for the California Department of Fish and Game, Balance Hydrologics installed a telemetered gaging station on the main stem of Gazos Creek roughly 0.5 miles from the mouth (**Figure H-1**). The gage was installed October 2nd 2001 and is referred to as the Gazos Creek-DFG telemetered gage (GCDFG). Parameters measured at the telemetered gage include water level (stage), water temperature and specific conductance. Drainage area at the gage is approximately 11.3 square miles. The

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[6] Specific electrical conductance (referred to in this report as specific conductance) "is the ability of a substance to conduct an electric current" (Hem, 1985) and is further defined as "the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature" (American Society for Testing and Materials, 1964). Balance Hydrologics reports specific conductance in units of µmhos (units of electrical conductance) per centimeter at 25 degrees Celsius. One µmho equals 10^6 mhos. Observations of specific conductance can be generally used as an index for "salinity" or ionic concentration.

Table H-1. Station Observer Log:
Gazos Creek at Cloverdale Road and Other Locations in the Watershed, January - December 2001

Site Conditions					*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage	Stage	Hydrograph	Measured Discharge	Estimated Discharge	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet) (at gage)*	*(feet) (at bridge)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
Site a. North Fork-above M-F confluence, Mt. Camp property															
1/19/2001	CWC	7.10	-	-	1.03	-	-	-	7	350	545	-	-	-	Installed staff gauge on Alder over left bank
3/16/2001	CWC	7.25	-	-	3.12	-	-	-	10	280	402	-	-	-	-
4/16/2001	CWC	7.14	-	-	1.81	-	-	-	10	300	431	-	-	-	High silt in channel. Well developed meander cut at right bank. Newts in channel.
6/9/2001	CWC	7.08	-	-	-	-	-	-	13	430	570	-	-	-	Cobbles and boulders covered with hundreds of egg cases. Banana slugs (light yellow) and mosquitos.
6/16/2001	CWC	7.08	-	-	-	-	-	-	13	380	503	-	-	-	Flow not measured b/c last staff rdg was w/in 0.10.
9/14/2001	CWC	7.08	-	-	0.73	-	-	-	12	470	639	-	-	-	-
11/10/2001	CWC								10	480	689	-	-	-	smokey from controlled burn in Big Basin
11/30/2001	CWC	-	-	-	18.61	-	-	-	9.5	-	-	-	-	-	Log jam under bridge at monitering site. Staff Guage bent almost flat by log.
12/8/2001	CWC	-	-	-	15.6	-	-	-	10	280	402	-	-	-	-
12/15/2001	CWC	-	-	-	-	-	-	-	6	240	384	-	-	-	Foam along banks; caterpillar-yellow & fuzzy.
Site b. Mid fork above confluence, upstream of pond, Mt. Camp property															
2/3/2001	CWC	0.26	-	-	0.50	-	-	-	9	330	487	-	-	-	-
2/16/2001	CWC	0.34	-	-	0.73	-	-	-	9	300	442	-	-	-	-
4/14/2001	CWC	0.34	-	-	0.31	-	-	-	9	350	516	-	-	-	Measured across cement ledge.
5/19/2001	CWC	0.3	-	-	0.41	-	-	-	12	350	476	-	-	-	-
6/9/2001	CWC	-	-	-	-	-	-	-	13.5	380	497	-	-	-	Flow obscured- no flow measured
7/28/2001	CWC	-	-	-	-	-	-	-	14	380	490	-	-	-	No flow measured.
8/3/2001	CWC	0.65	-	-	0.30	-	-	-	13	400	530	-	-	-	Water surface appears to have slight layer of film.
12/8/2001	CWC	-	-	-	2.37	-	-	-	10	340	488	-	-	-	-
12/15/2001	CWC								8	330	500	-	-	-	
12/21/2001	CWC	0.78	-	-	8.30	-	-	-	10	220	316	Qss, Qbl	-	-	TSS sample taken. Bedload samp.

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Site Conditions					*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time (mm/dd/yr)	Observer(s)	Stage (feet) (at gage)	Stage (feet) (at bridge)	Hydrograph (R/F/S/B)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Instrument Used (AA/PY)	Estimated Accuracy (e/g/f/p)	Water Temperature (oC)	Specific Conductance at field temp. (µmhos/cm)	Specific Conductance at 25C (at 25 oC)	Additional sampling? (Qbed, etc.)	Estimated stage at staff plate (feet)	Inferred dates? (mm/dd/yr)	
Site c. South Fork above confluence (a.k.a., Bear Gulch), downstream of first road crossing															
1/19/2001	CWC	4.2	-	-	0.28	-	-	-	8	210	318	-	-	-	Installed staff plate at large root that crosses stream, 30' upstream of flow x-section.
3/3/2001	CWC	1.12	-	-	2.93	-	-	-	10	160	230	-	-	-	New Staff plate installed today.
4/16/2001	CWC	-	-	-	0.69	-	-	-	10.5	160	227	-	-	-	Staff plate stolen.
5/12/2001	CWC	-	-	-	0.45	-	-	-	12	190	258	-	-	-	Mosquitos and abundant baby banana slugs +/- 1".
6/9/2001	CWC	-	-	-	0.21	-	-	-	13.5	190	248	-	-	-	Many fish sighted (15-30 in number) 1"- 2.5" in size. Newts, millipedes, centepedes, mayfly larva, and a dragonfly spotted. Very little canopy over creek.
6/16/2001	CWC	-	-	-	0.23	-	-	-	14	190	245	-	-	-	Took pH sample 5' d/s of iron bacteria deposit.
8/3/2001	CWC	-	-	-	0.07	-	-	-	14	210	271	-	-	-	Fish 1.5"-2"
10/6/2001	CWC	-	-	-	0.05	-	-	-	13	-	-	-	-	-	-
11/17/2001	CWC	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-
12/15/2001	CWC	-	-	-	-	-	-	-	10	190	273	-	-	-	-
Site d. Gazos Creek at Cloverdale Road (200' upstream of Old Woman Rd. bridge)															
2/3/2001	CWC	-	-	-	2.76	-	-	-	6	320	512	-	-	-	Alder down from creek bank (left) slumped into creek.
3/4/2001 11:15	jo, cw	-	-	?	22.4	15-20	PY	f	10.6	165	233	Qss, Qbed	-		gravel and sand moving, creek noticeably more downstream from measurement point
3/31/2001	CWC	-	-	-	5.72	-	-	-	11	280	391	-	-	-	-
4/28/2001	CWC	-	-	-	4.68	-	-	-	11.5	310	427	-	-	-	-
5/4/2001	CWC	-	-	-	3.75	-	-	-	10.5	280	397	-	-	-	-
6/1/2001	CWC	-	-	-	2.21	-	-	-	14.5	300	382	-	-	-	-
6/19/2001 16:30	sds, rd	-	8.28	B	1.49	1	PY	?	16.5	285	344	-	-	-	Monitoring equipment installed roughly 200' upstream of Cloverdale Road Bridge, sunny
6/27/2001 10:10	CWC	4.82	-	B	-	-	-	-	-	-	-	-	-	-	-
6/29/2001 9:47	CWC	-	8.28	B	1.51	-	ACM	?	14.0	320	413	-	-	-	Clear
7/18/2001 18:45	sds	4.80	8.25	B	1.183	-	PY	g	15.3	285	355	-	-	-	Foggy
7/21/2001 0:00	CWC	-	-	-	-	-	-	-	14	390	503	-	-	-	3 fish.
8/18/2001	CWC	-	-	-	0.90	-	-	-	13.5	400	523	-	-	-	-
8/23/2001 18:42	gp	4.79	8.25	B	1.4	-	PY	?	16.9	315	377	-	-	-	Clear with fog rolling in

Table H-1. Station Observer Log:
Gazos Creek at Cloverdale Road and Other Locations in the Watershed, January - December 2001

Site Conditions					*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage	Stage	Hydrograph	Measured Discharge	Estimated Discharge	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet) (at gage)*	*(feet) (at bridge)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
Site d. continued															
8/31/2001	CWC	-	8.28	B	1.03	-	-	-	14	-	-	-	-	-	Foggy
9/18/2001 14:30	sds	4.74	8.25	B	0.909	-	PY	e	14.2	291	373	-	-	-	Foggy and cool
9/29/2001 0:00	CWC	-	8.27	-	-	-	-	-	12	410	558	-	-	-	-
10/18/2001 18:30	cw, sds	4.78	8.21	B	0.79	-	PY	g	13.1	290	383	-	-	-	Fog rolling in
10/19/2001 9:17	CWC	-	8.22	B	0.81	-	ACM	?	10.5	430	609	-	-	-	Clear
10/27/2001	CWC	-	8.20	B	1.10	-	ACM	?	12.0	410	558	-	-	-	Cloudy
11/16/2001 8:45	bh	4.88	-	?	2.50	-	-	- -	-	-	-	-	5.75	11/11/2001	Remove datalogger
11/29/2001 7:30	bjm, sds	-	-	F	-	117 +- 17	Float	-	-	-	-	Qss, Qbed	-	~ BF on 11/28	Log jam where gage was located blew out during storm, staff plate is gone
12/2/2001 16:30	sds, cw	3.7-3.9 (fg)	-	F	-	300 +- 16	Float	-	-	-	-	Qss, Qbed	-	-	-
GCDFG gage. Main stem-above lagoon near mouth of Creek, at roughly stream mile 0.7east of Highway 1, Fish and Game Gage															
2/3/2001	CWC	0.8	-	-	3.71	-	?	?	-	-	-	-	-	-	
2/16/2001	CWC	1.06	-	-	10.14	-	?	?	-	-	-	-	-	-	
3/3/2001	CWC	-	-	-	13.10	-	?	?	-	-	-	-	-	-	
3/31/2001	CWC	0.91	-	-	6.29	-	?	?	-	-	-	-	-	-	
4/28/2001	CWC	0.9	-	-	6.30	-	?	?	-	-	-	-	-	-	
5/19/2001	CWC	-	-	-	3.11										
6/29/2001 16:20	rd	0.7	-	B	1.61	-	PY	f	-	-	-	-	-	-	Rachel Davis conducted work
8/18/2001	CWC	0.66	-	-	1.04	-	-	-	-	-	-	-	-	-	
8/31/2001	CWC	0.68	-	-	1.28	-	-	-	-	-	-	-	-	-	
9/18/2001 14:00	sds	0.65	-	B	0.99	-	PY	?	14.1	301	387	-	-	-	Disturbed control at d/s end of pool
10/19/2001 9:50	sds, cw	0.64	-	B	0.96	-	PY	e	11.4	252	348	-	-	-	
11/15/2001 17:30	sds	0.78	-	B	2.40	-	PY	g	12.5	283	380	-	-	-	3 days after 1st major storm of year
11/29/2001 7:45	sds, bjm	2.42	-	F	111.5	-	AA	g	-	-	-	Qss, Qbl	4.15	11/29/2001 3:00	
11/29/2001 10:45	sds, bjm	2.03	-	F	77.3	-	AA	?	-	-	-	Qss, Qbl	-	-	
12/2/2001 17:20	sds, cw	3.5	-	F	262.0	-	AA	g	12.5	118.43	159	Qbl	-	-	
12/14/2001 9:00	jo	2.04	-	F	42.3	-	AA	e-g	11.5	183	252	Qss, Qbl	-	-	water light brown, visibility 2"
12/21/2001 11:45	jo, mc	2.6	-	F	-	100	-	-	-	-	-	Qss, Qbl	-	-	
12/28/2001 17:15	sds, bjm	1.82	-	U	32.4	-	AA	?	-	-	-	Qss, Qbl	-	-	possible ponding from lwd d/s of gage

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Date/Time *(mm/dd/yr)*	Observer(s)	Stage *(feet) (at gage)*	Stage *(feet) (at bridge)*	Hydrograph *(R/F/S/B)*	Measured Discharge *(cfs)*	Estimated Discharge *(cfs)*	Instrument Used *(AA/PY)*	Estimated Accuracy *(e/g/f/p)*	Water Temperature *(oC)*	Specific Conductance at field temp. *(µmhos/cm)*	Specific Conductance at 25C *(at 25 oC)*	Additional sampling? *(Qbed, etc.)*	Estimated stage at staff plate *(feet)*	Inferred dates? *(mm/dd/yr)*	
Site f. Slate Creek above confluence, streamside of Gazos Road and Gazos Creek upstream of the Slate Creek Confluence															
5/4/2001	CWC	-	-	-	0.26	-	-	-	10.5	250	354	-	-	-	discharge measured on Slate Creek
7/28/2001	CWC	-	-	-	-	-	-	-	15	410	515	-	-	-	-
8/3/2001	CWC	-	-	-	0.79	-	-	-	14.5	400	509	-	-	-	discharge measured on Gazos Creek
8/18/2001	CWC	-	-	-	0.69	-	-	-	12	240	327	-	-	-	discharge measured on Gazos Creek
9/14/2001	CWC	-	-	-	0.81	-	-	-	-	420	-	-	-	-	discharge measured on Gazos Creek
10/6/2001	CWC	-	-	-	0.83	-	-	-	13	-	-	-	-	-	discharge measured on Gazos Creek
Site g. Highway 1, under Bridge															
3/16/2001	CWC	-	-	-	10.74	-	-	-	11	290	405	-	-	-	-
4/28/2001	CWC	-	-	-	5.34	-	-	-	13.5	350	458	-	-	-	-
6/16/2001	CWC	-	-	-	1.42	-	-	-	12	380	517	-	-	-	-
6/29/2001	CWC	-	-	-	0.46	-	-	-	15	420	528	-	-	-	Fish trapped in pool at diversion. Human feces.
7/28/2001	CWC	-	-	-	-	-	-	-	14	410	529	-	-	-	Human feces present on Right Bank just below diversion
8/18/2001	CWC	-	-	-	0.04	-	-	-	14.5	410	522	-	-	-	-
11/10/2001	CWC	-	-	-	-	-	-	-	10	420	603	-	-	-	-
Site h. Downstream of S-Fork, this site represents flow from the north, middle and south forks															
4/16/2001	CWC	-	-	-	2.97	-	-	-	10	270	388	-	-	-	Wide glide approximately 1' depth. Large amount of silt.
6/1/2001	CWC	-	-	-	1.08	-	-	-	15	350	440	-	-	-	
6/9/2001	CWC	-	-	-	2.27	-	-	-	15	360	452	-	-	-	~10 fish 4-6" in glide. ~7-8 newts in h2o. Below falls in pool+ numerous fish.
10/19/2001	CWC	-	-	-	0.81	-	-	-	11	440	615	-	-	-	-
Miscellaneous one-time measurements															
1/2/2002	sds, jo	1.55-1.70	-	-	-	30	-	-	-	-	-	Qss, Qbl	-	-	Measurements made on Middle Fork at site b.
1/2/2002	sds, jo	-	-	R	-	45	-	-	-	-	-	Qss, Qbl	-	-	Measurements made on South Fork at site c.
1/2/2002	sds, jo	-	-	R	-	50	-	-	12.9	123	-	Qss	-	-	Measurements made on Old Woman Creek
1/2/2002	sds, jo	4.9	-	R	-	-	-	-	-	-	-	Qss, Qbl	-	-	Measurements made at the DFG gage, u/s of diversions
1/3/2002	sds, jo	-	-	-	-	16	-	-	-	-	-	Qss, Qbl	-	-	Measurements made on Slate Creek.

Observer Key: jo = Jonathan Owens; bh = Barry Hecht; gp = Gustavo Porras; sds = Dave Shaw; bjm = Bonnie Mallory; smc = Shawn Chartrand; mc = Maya Conrad; rd = Rachel Davis
Observer Key cont.: CWC: Varied Coastal Watershed Council staff and volunteers
Stage: Water level observed at outside staff plate, (us) = Staff plate located near the monitoring equipment, (ds) = staff plate located at the Cloverdale Road Bridge, (fg) = fish and game gage located near Highway 1
Hydrograph: Describes stream stage as rising (R), falling (F), steady (S), or baseflow (B)
Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter, analog current-meter (ACM). If estimated, from rating curve (R) or visual (V).
Estimated measurejfent accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given
High-water mark (HWM): Measured or estimated at location of the staff plate
Specific conductance: Measured in micromhos/cm in field; then adjusted to 25degC by equation (1.8813774452 - [0.050433063928 * field tejfp] + [0.00058561144042 * field tejfp^2]) * Field specific conductance
Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate
lwd: large woody debris

draft data report for water year[7] 2002 has been included in this report as **Appendix H-S**. The report presents the annual record of streamflow and sediment discharge as well as the records of water temperature and specific conductance for the GCDFG gage.

H.1.3.3 Coastal Watershed Council monitoring stations

In addition to continuously collected stream gage data by Balance, Coastal Watershed Council staff and volunteers collected water quality data and conducted point streamflow measurements at twelve different locations throughout the watershed from January 2001 to December 2001. **Figure H-1** illustrates the locations of monitoring stations of which data collected at each station was utilized in the assessment project. The following table presents general information for these monitoring stations:

Site I.D[8]. and Name	Drainage Area at Site	General Location
Site a: North Fork Gazos Cr.	~ 2.13 square miles	~ 500 feet upstream of Middle Fork confluence
Site b: Middle Fork Gazos Cr.	~ 1.17 square miles	~ 200 feet upstream of mainstem confluence
Site c: South Fork Gazos Cr. (a.k.a. Bear Gulch)	~ 0.93 square miles	~ 300 feet upstream of mainstem confluence
Site d: Cloverdale Road Bridge (same as GCCR gage)	~ 8.0 square miles	At the Cloverdale Road Bridge and ~ 200 feet upstream of the bridge (GCCR gage)
Site f: Slate Creek and Gazos Creek above Slate Creek	~ 1.0 square miles	Slate Creek: in between Gazos Creek and Gazos Creek road Gazos Creek: just upstream of Slate Creek confluence
Site g: Gazos Creek downstream of diversions	~ 11.4 square miles	~ 1000 feet downstream of diversions
Site h: Gazos Creek (a.k.a. sum site)	~ 4.3 square miles	Immediately downstream of confluence with South Fork

Data collected at each of these stations from January to December 2001 is presented in **Table H-1.** It should be noted that not every station monitored in the watershed by

[7] A water year is defined as the period October 1st of any given year through September 30th of the following year with the following year serving as the year marker. For example, water year 2002 is defined by the period October 1st 2001 through September 30th 2002.
[8] I.D. refers to the site identification system used in the Station Observer Log and that represented in Figure H-1.

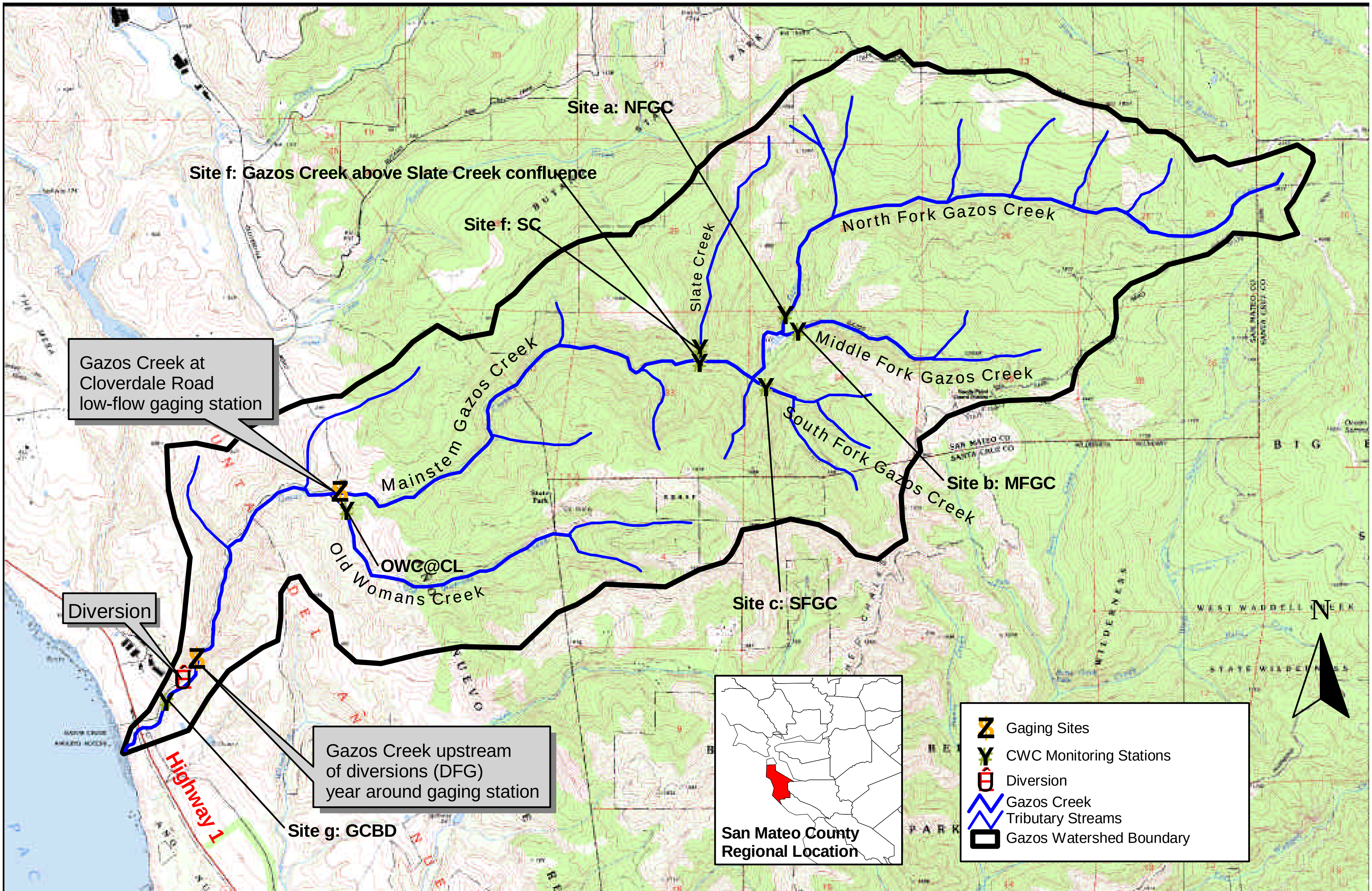

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Figure H-1 Gazos Creek Watershed, San Mateo County, California.

Gazos Creek watershed showing major streams and its position between Butano and Waddell Creek basins. Locations of gages and monitoring sites are shown

CWC during the assessment project was cited in Table H-1 due to lack of relevant data or station duplicity in conjunction with stream gaging.

H.2 Hydrologic Assessment Results

H.2.1 GCCR gaging records

Figure H-2 illustrates the 15-minute baseflow record for Gazos Creek at Cloverdale Road for the period June 19th to November 16th, 2001. Also illustrated with the record of baseflow are manual flow measurements collected by CWC at the gage as well as air temperature and rainfall recorded at the nearby Chalks[9] station managed by California Data Exchange (*http://water.cdec.ca.gov*). For the period of operation, daily mean baseflows at the GCCR gage primarily ranged from 2.0 to 0.50 cfs with the lower flows occurring later in the summer. This seasonal characteristic of flow is typical of streams within a Mediterranean-type ecosystem. The three streamflow peaks recorded on October 30th, November 11th and November 12th correspond to early season rain events.

Figure H-3 illustrates the water temperature and specific conductance record for the GCCR gage. Over the gaging period, 15-minute water temperatures ranged from roughly 9 to 18 degrees Celsius while 15-minute specific conductance ranged from 320 to 400 µmhos. In general during 2001, water temperatures steadily declined over the course of the summer while specific conductance generally rose. This trend is sharply punctuated in early November in response to rain recorded from November 10th to November 15th, 2001. During these rains, specific conductance fell almost 150 µmhos while water temperature rose about 1.5 degrees Celsius. Drops in specific conductance associated with rain events are not uncommon as rain is generally less 'saline' than ground water; the response to water temperature can be more variable due to the occurrence of relatively 'warm' and 'cool' storms.

Table H-1 illustrates the assessment observer log, which includes the GCCR stream gage as well as numerous other monitoring locations in the watershed. The observer log is a record of all measurements and observations made by Balance staff, and in this instance by CWC staff and volunteers in the watershed which are associated with this assessment project.

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[9] Air temperature and rainfall recorded at Chalks is available through the California Data Exchange website (cdec.water.ca.gov) by following links for precipitation. The station I.D. for Chalks is CKS.

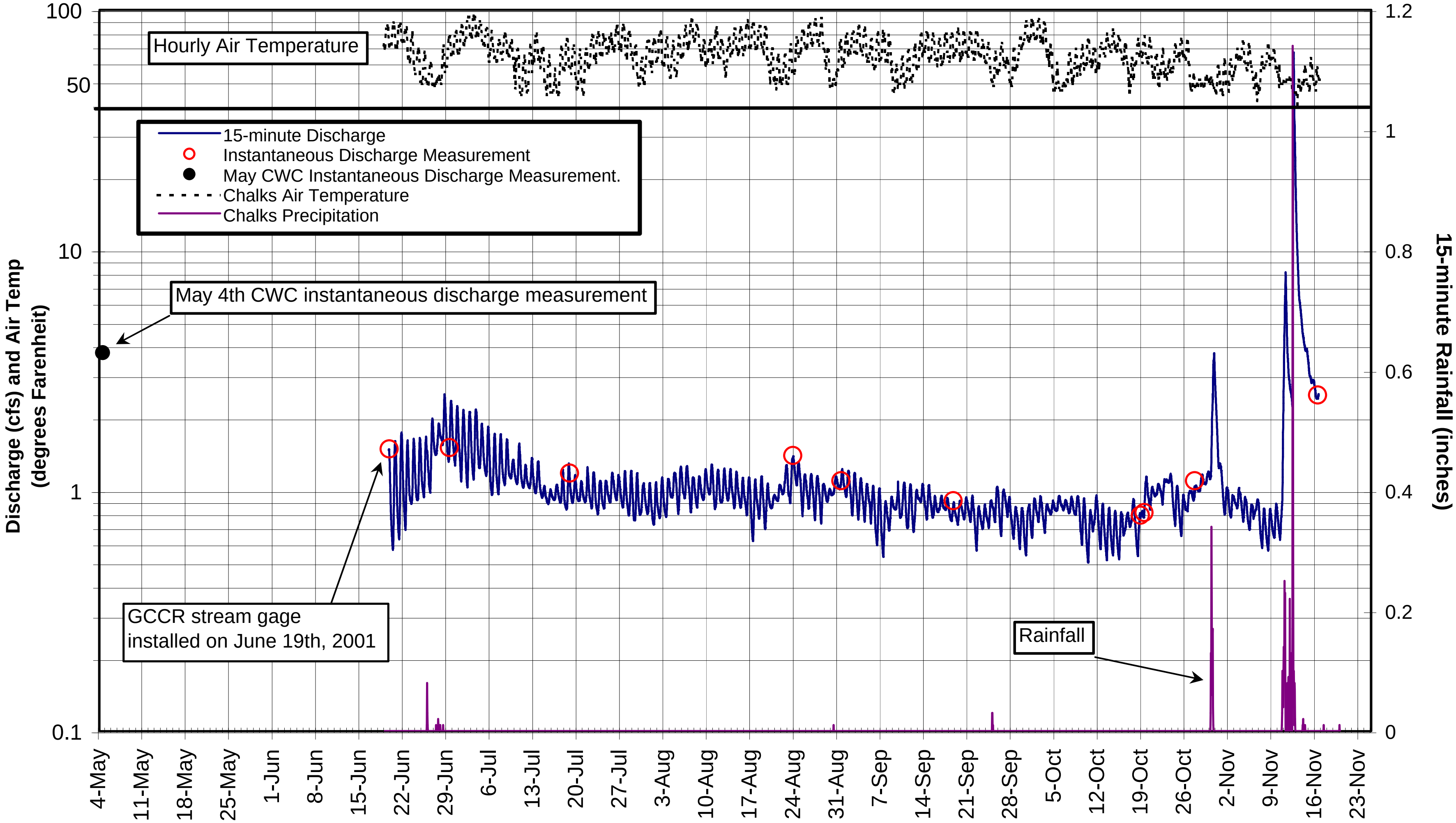

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Figure H-2: Baseflow discharge and manual measurements of baseflow discharge, Gazos Creek at Cloverdale Road, San Mateo County, California, June 19 through November 16, 2001. Concurrent 15-minute rainfall and air temperature measured at the nearby Chalks CDEC station are shown. Note that both streamflow and daily streamflow fluctuations respond to changes in

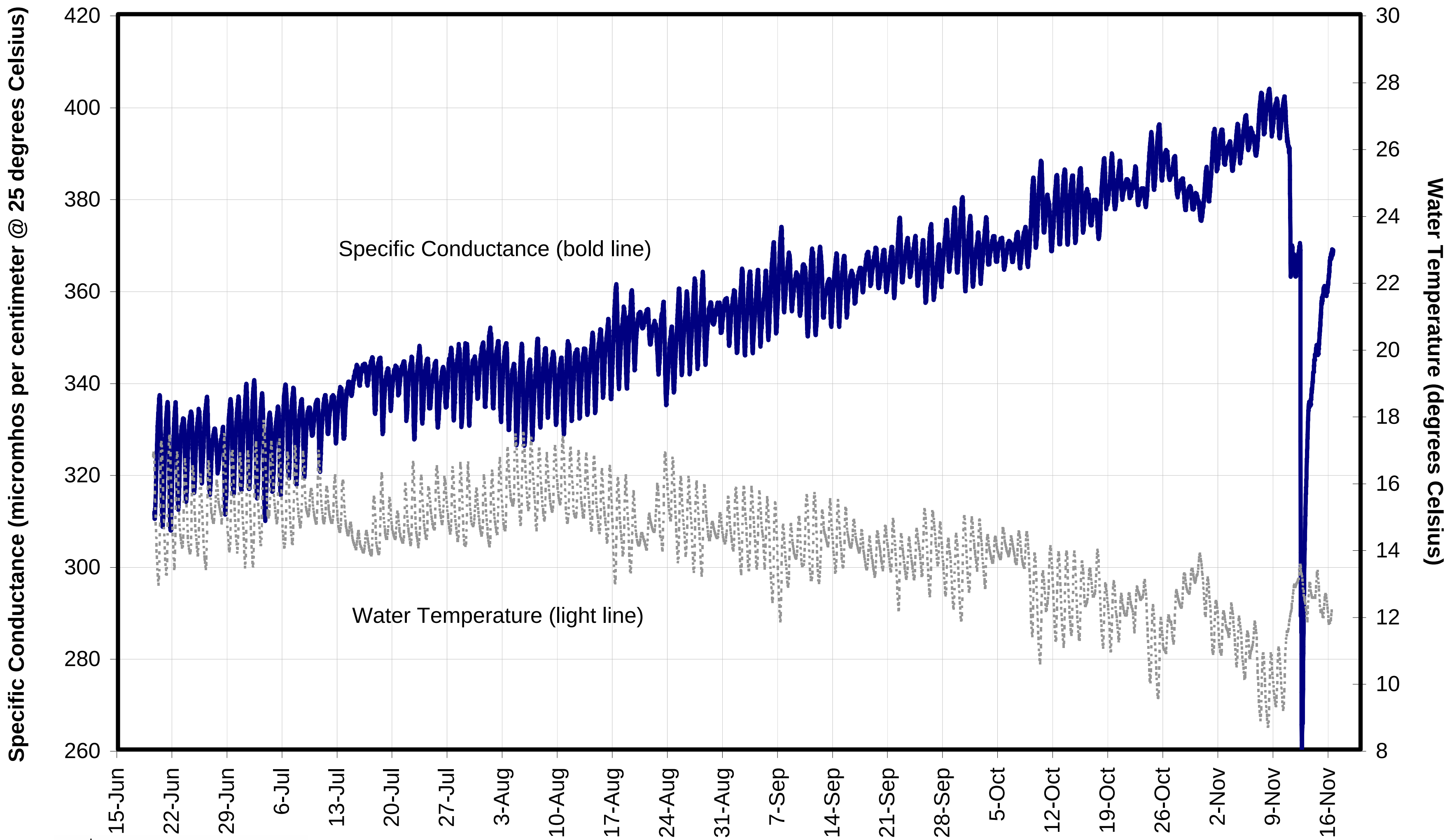

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Figure H-3: Specific conductance and water temperature, June 19th to November 16th, 2001, Gazos Creek at Cloverdale Road, San Mateo County, California. Specific conductance and water temperature data are 15-minute average values. Sharp fluctuations present in the 15-minute data are on the scale of approximately 12-hour periods indicating diurnal (night-day) effects. The maximum 15-minute temperature for the season was 17.5 degrees Celsius on August 5th at 16:45.

200022_WY01_GCCR_Q.xls,SC and WT

H.2.2 Sources of low-flows

Figure H-4 illustrates point measurements of baseflow discharge collected by CWC along with the continuous records of discharge for the GCCR and GCDFG stream gages for the period May to December 2001. As mentioned above in **Section A.1.3.3,** the full account of baseflow measurements made in the watershed is presented in **Table H-1.** Several points can be made about the baseflow data illustrated in this figure:

1. Measured baseflow generally increased from the GCCR gage to the GCDFG gage from June to November 2001. Synoptic measurements at the two gages on June 29th, August 31st and October 19th indicate a net increase in baseflow from 7 to 15 percent from the GCCR gage downstream to the GCDFG gage. Measurements made on November 15th, however indicate a net loss in flow of 4 percent from the GCCR gage to the GCDFG gage[10].

2. The proportion of baseflow originating out of the three primary upper watershed tributaries (North, Middle and South Forks) is likely to be variable at the daily level. Additional data are needed to better describe baseflow contribution from each of the upper watershed primary tributaries. The limited dataset collected as a part of this assessment, however, suggests the following as a possible range of daily baseflow characteristics for the upper watershed and the mainstem to the GCCR gage location:

   a. *The Middle and South Forks could account for up to 50% of baseflow discharge which originates out of the upper watershed.*

   Synoptic baseflow measurements made on August 3rd, 2001 suggest that baseflow originating from the Middle and South forks accounted for roughly 50 percent of total flow measured above the Slate Creek-Gazos Creek mainstem confluence, on that day. If we assume that (1) ground water discharge and inflow from smaller tributaries to the mainstem from the South Fork to Slate Creek was zero on August 3rd and (2) there was no net loss of surface flow from the South Fork to Slate Creek on August 3rd,

[10] Measurements made on November 15th 2001 are slightly more difficult to interpret at face value due to their association with an early season storm event.

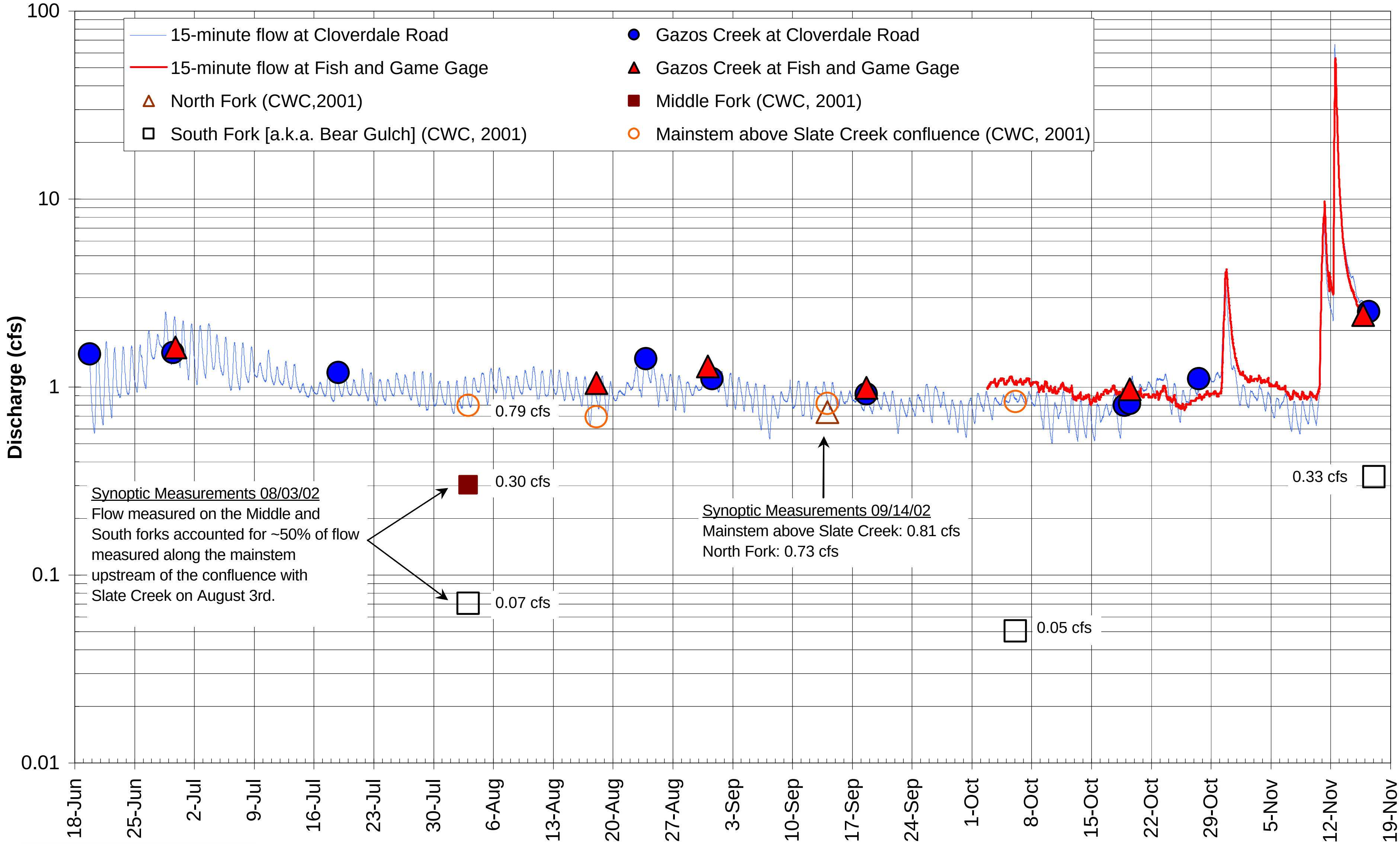

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Figure H-4: Records of flow on Gazos Creek at various locations in the upper, mid and lower watershed, June 19 through November 16, 2001, San Mateo County, California. Continuous records of flow are shown for our gages at Cloverdale Road and above the diversion on the lower mainstem of Gazos. Hand-measurements of flow at various locations and on various days are also shown.

200022_WY01_GCCR_Q.xls,GCCR_20min+US_Qmeas then the remaining 50% of the measured flow presumably originated from the North Fork.

b. *The North Fork could contribute at least 50% of the total baseflow originating from the upper watershed.*

Measurements made on August 3rd, 2001indicate that the North Fork accounted for roughly 50% of baseflow originating out of the upper watershed on that day (see point a above per assumptions) while measurements made on September 14th, 2001 indicate that on this day the North Fork accounted for roughly 90 percent of total flow originating out of the upper watershed tributaries[11]. The difference between results of August 3rd and September 14th could be attributable to:

- the accuracy of the flow measurements, and / or
- actual day to day variation in baseflow discharge from the upper watershed primary tributaries (North, Middle and South forks),
- impacts on daily baseflows from unknown stream water withdraws in the upper watershed tributaries and / or
- time fluctuations in hydrologic response from various variables such as evapotranspiration due to differences in total stream length[12] in each of the three upper watershed tributaries.

3. For the reach between Slate Creek and the GCCR gage, Slate Creek, smaller tributaries along this reach and ground water discharge to the mainstem of Gazos Creek along this reach could account for roughly 5% to 15% of total flow recorded at the GCCR gage[13]. The continuous record of flow at the

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[11] Again, we are assuming that on August 3rd ground water discharge to the channel and inflow from smaller tributaries in between the South Fork and Slate Creek was zero and that there was no net loss in surface flow from the South Fork to Slate Creek.
[12] For example, the affect of evapotranspiration on streamflow from the north fork would be delayed when compared to the same process on the middle or south fork because the total stream length of the north fork is longer than either of the other two forks.
[13] This result does not account for the possibility of surface flow loss along this reach due to infiltration of some portion of total flow into stream gravels on the bed. If this did not occur, the flow would not be lost from the system but would rather occur as sub surface flow through the gravels possibly re-surfacing at a point downstream where substrate conditions force flow to the surface.

GCCR gage compared to baseflow measurements made on the mainstem of Gazos Creek at Slate Creek on August 3rd, August 18th, September 14th and October 6th (2001) indicate that Slate Creek, smaller tributaries in between these two stations and ground water discharge to the stream along this reach accounted for 8% to 14% of total flow recorded at the GCCR gage, on those four days.

H.2.3 Bankfull discharge at the GCDFG gage

In January of 2002, fieldwork was conducted at the GCDFG gage to collect information needed for calculation of bankfull discharge at the gage. The work involved conducting a level-survey of cross-sectional geometry through the GCDFG gage. During the level-survey, important surfaces and gage structures such as the morphologic bankfull surface and the top of the staff plate were sited and noted. The procedure used in calculating bankfull discharge at the gage is discussed in **Appendix H-C** of this report. The cross-section surveyed through the GCDFG gage is illustrated in **Figure H-5.** Elevations displayed on the y-axis in **Figure H-5** correspond to water level or stage which is measured from the staff plate at the gage. Bankfull flow for the telemetered gage station was calculated to be about 840 cfs, or about 74 cfs per square mile. Peak flow calculated for water year 2002 was 933 cfs, and is based on the instantaneous peak stage recorded at the gaging station.

H.2.4 1982 and 1998 Discharge Calculations at the GCDFG gage

The cross-sectional survey performed in January 2002 also aided calculation of flows associated with high water marks from water years 1982 and 1998. **Figure H-5** illustrates the relative locations of high water marks believed to be associated with peak events during water years 1982 and 1998. The procedure described in **Appendix H-C** was also used to calculate peak flows from 1982 and 1998; results from the calculations are presented in **Table H-2.** Appendix H-S presents a complete account of the evidence used in assigning ages to high water marks measured in the cross section. The peak flow[14] calculated for the 1982 high water mark is roughly 4,800 cfs and the peak flow for the 1998 high water mark is roughly 3,000 cfs.

[14] Average of the lower and upper estimates of velocity (flow) associated with the high water mark.

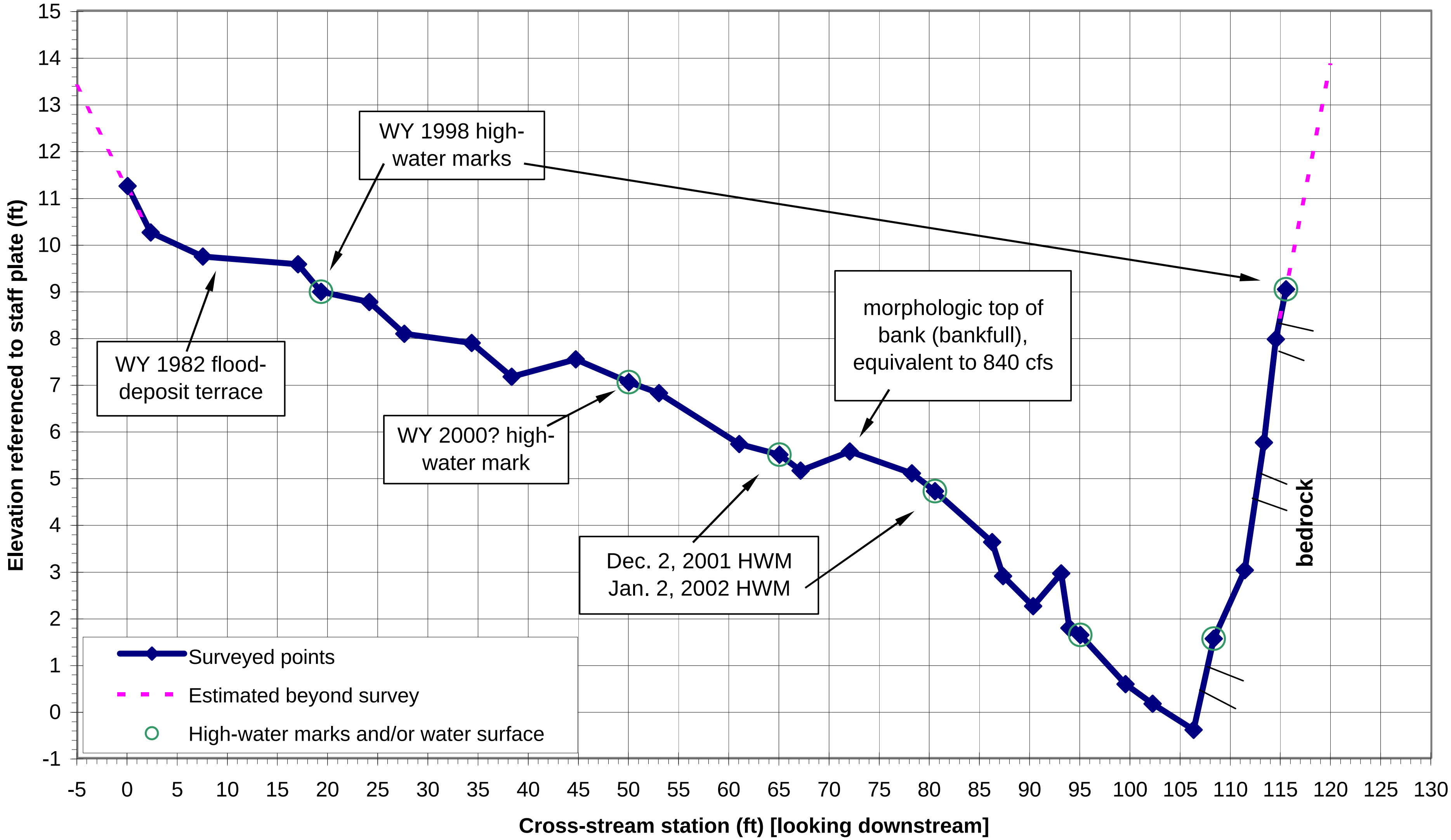

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Figure H-5. Cross-section survey plot: Gazos Creek, about 1/2 mile upstream of Highway 1. Survey performed 1/17/02 at the gaging station (also referred to as Site e or GCDFG). We calculated bankfull flow to be about 840 cfs at this site, where "morphologic bankfull" and "recurrence-interval bankfull" (1.5- to 2-year flood) seem to be in agreement.

Table H-2. Peak flow calculations:
Gazos Creek above Highway 1

Water year	Peak Stage	Flow Area at Peak Stage	Average Velocity at Peak Flow	Peak Flow	
	(ft)	*(ft^2)*	*(ft/s)*	*(cfs)*	
1998	9.0	360	9.0	3240	using upper estimate of velocity
1998	9.0	360	7.5	2700	using lower estimate of velocity
				2970	average
1982	10.5	510	10.5	5355	using upper estimate of velocity
1982	10.5	510	8.4	4284	using lower estimate of velocity
				4820	average

Notes:

Flow area based on cross-section survey at DFG site (see Figure H-5).

Velocity estimates based on extrapolation of measured velocity at lower water levels.

We did not find distinct terraces from Dec. 1955 at this site; we suspect that the peak flow depth in Dec. 1955 was about the same as in January 1982. This agrees with our observations that 1982 terraces are at about the same elevation as 1955 terraces in many locations along Gazos Creek.

H.2.5 Peak flows

Residents long-familiar with the creek report that the early-February 1998 peak flow in Gazos Creek was the largest since January 1982. There do not appear to be residents in the area who observed the December 1955 event, so we do not know from first-hand information how this flood compared with the 1982 crest. It should be noted that flood magnitudes differ from those in Pescadero, where the 1998 event is reported to be the flood of record. The heaviest rains of the February 1998 storm are known to have tracked a narrow path through the San Gregorio, Pescadero and San Francisquito watersheds, and then easterly through the mountains south of Livermore to the Del Puerto and Salado watersheds near Patterson. **Figure H-6** presents the record of annual instantaneous peak streamflows for Pescadero Creek as reported by the U.S. Geological Survey, Pescadero Creek near Pescadero, No. 11162500, 1953-2001. Despite the close proximity of Pescadero Creek to Gazos Creek, the magnitude of historic peak streamflows recorded in Pescadero Creek do not necessarily describe the history of peak streamflows in Gazos Creek. The primary reason for this caution is that winter storms in some water years along the central California Coast, for instance 1986, 1998 and 1999, were spatial quite variable in terms of storm magnitude. Exceptions to major winter storms which were spatially variable were those winter storms during January 1982 and (especially) December 1955, which affected a large geographic area in California (Blodgett and Poeschel, 1988; Blodgett and Chin, 1989; Goodridge, 2000).

Data presented in **Appendix H-D** show that the peak from the 1998 storm progressively diminished southeastward in the San Lorenzo and Soquel watersheds; previously, Balance Hydrologics staff reported this peak as becoming progressively smaller to the north, in the Mills, upper Pilarcitos and Apanolio watersheds, respectively (Owens and others, 2001). The January 1982 event is reported as having generated both higher creek crests and more landslides (Debbie and Randy Bennett, Peter Twight, pers. comm.); Gazos Creek Road was closed ~1-2 miles below Mountain Camp for approximately 6 months after this storm.

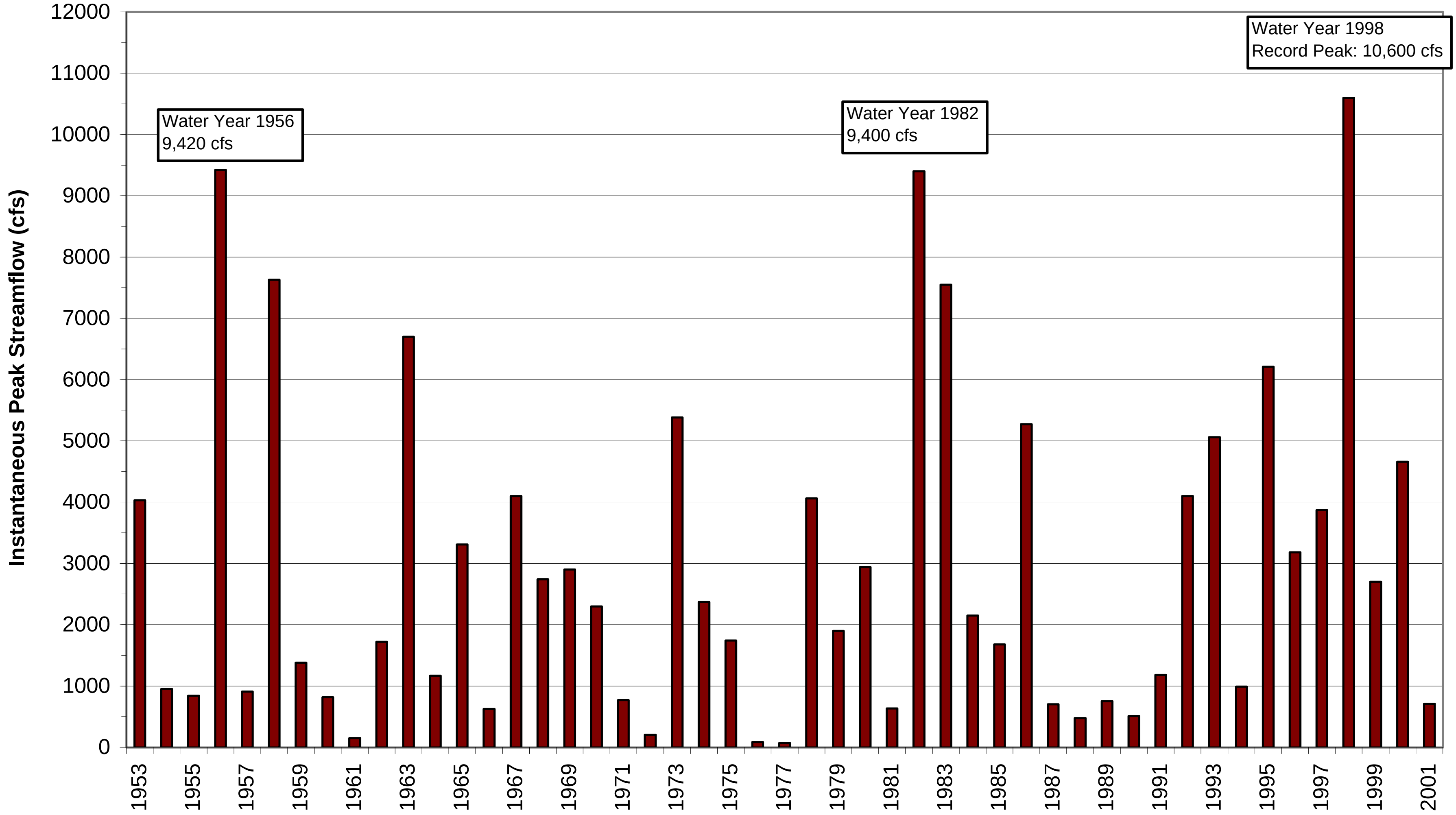

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Figure H-6: Record of annual instantaneous peak streamflows for Pescadero Creek as reported by the USGS for Pescadero Creek near Pescadero, I.D. 11162500, water years 1953 through 2001, San Mateo County, California. Pescadero Creek is located roughly 5 miles north of the mainstem Gazos Creek and has a drainage area at the gage of roughly 46 miles^2.

Pescadero_Annual _Peaks, Pesc_Annual_Peaks

H.3 Hydrologic Assessment Discussion

H.3.1 Sources of baseflow in Gazos Creek

Figure H-4 illustrates synoptic measurements of baseflow made in the upper watershed along with continuous records of streamflow for the GCCR and GCDFG gages, June 19th to November 16th 2001. Two different sets of synoptic measurements made during this period suggest baseflow sources and magnitudes of sources in Gazos Creek. Measurements made on August 3rd indicate that together, the Middle and South Forks of Gazos Creek accounted for roughly 50% of streamflow measured along the mainstem, above the confluence with Slate Creek. If we assume that ground water contribution and inflow from smaller tributaries along the reach from the South Fork to Slate Creek was zero on August 3rd; the remaining 50% of streamflow would have presumably originated from the North Fork. On September 14th, synoptic measurements were made on the North Fork and again along the mainstem above the confluence with Slate Creek. This set of measurements suggest that the North Fork accounted for 90% of streamflow measured along the mainstem, with the remaining 10% to have originated from the Middle and South Forks[15]. For both sets of measurements, the North Fork accounted for the highest percentage of streamflow originating in the upper watershed. It is important to note that these results are based on two days of synoptic measurement data and that additional data is needed to better describe baseflow sources and magnitudes of these sources for the upper watershed. As was stated above in section A.2.2, the difference in results from synoptic measurements made on August 3rd and September 14th, 2001 could be due to (1) error associated with the actual measurements, (2) actual day to day variability in baseflow discharge from the three upper watershed tributaries and (3) impacts to daily flow from unknown direct stream withdraws or diversions in the upper watershed. Given the range of variability present in the data, it seems reasonable to suggest that this range is likely due to measurement errors rather than natural variability in groundwater discharge along the upper watershed tributaries.

Based on results from our limited dataset, the possible range of baseflow distributions from the upper watershed tributaries is not surprising given their respective watershed areas. The drainage area of the North Fork is 2.13 square miles, the Middle Fork is 1.17

[15] Assuming again that ground water contribution and inflow from smaller tributaries along the reach from the South Fork to Slate Creek was zero.

square miles while the South Fork is 0.93 square miles. Given that the North Fork is roughly two times as large as either the Middle or South Forks, we would expect the North Fork to contribute higher rates of baseflow to the mainstem. In addition to the effects of drainage area on baseflow contribution, a large percentage of the North Fork is underlain by the locally steeply dipping Butano Sandstone[16,17]. It is possible that this unit is locally important in sustaining baseflows through the summer months.

H.3.2 Regional comparison of baseflow hydrology

Figure H-7 illustrates rates of baseflow per mile^2 of drainage area for Gazos Creek at Cloverdale Road, San Geronimo Creek at Lagunitas Bridge (SG) and Corte Madera Creek at Westridge Drive (CM) for the period May 1st to September 30th, 2001[18]. San Geronimo Creek is located in Marin County with the gage found at the Lagunitas Bridge while Corte Madera Creek is located in San Mateo County with the gage found at the Westridge Drive Bridge (**Figure H-8**)[19]. San Geronimo at Lagunitas Bridge and Corte Madera at Westridge Drive have similar drainage areas to Gazos Creek at Cloverdale Road (8.7, 6.0 and 8.0 miles^2, respectively) but have slightly different watershed averaged mean annual precipitation (43, 30 and 35 inches / year, respectively; Rantz, 1971). Rates of baseflow were compared in order to characterize Gazos Creek baseflow hydrology on a regional scale.

Figure H-7 clearly illustrates larger rates of baseflow per square mile of drainage area in Gazos Creek as compared to San Geronimo and Corte Madera Creeks for water year 2001. Rates of baseflow per square mile in Gazos Creek vary from 2.5 to 35 times greater than rates for San Geronimo and from 2.5 to roughly 100 times greater than rates in Corte Madera. Due to a lack of mean daily flow data for Gazos Creek from May 1 through June 19, 2001, rates of baseflow recession for these three watersheds cannot be

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[16] A segment of the Johansen anticline axis is located in the upper reaches of the North Fork of Gazos Creek (Brabb and Pampeyan, 1972). Locally, the anticline axis strikes roughly north 45 degrees west, the North Fork of Gazos Creek has a rough westerly trend, upstream of the Santa Margarita Formation.

[17] Locally, Clark, Brabb and McLaughlin (1989) described the Butano Sandstone as a medium-bedded to massive fine-to medium- grained arkosic sandstone with thin interbeds of siltstone and shale

[18] In many parts along the central California coast, water year 2001 was a normal to slightly below normal year in terms of precipitation.

[19] Streamflow data for San Geronimo and Corte Madera Creeks are from data gleaned from gages operated by Balance Hydrologics staff (see references).

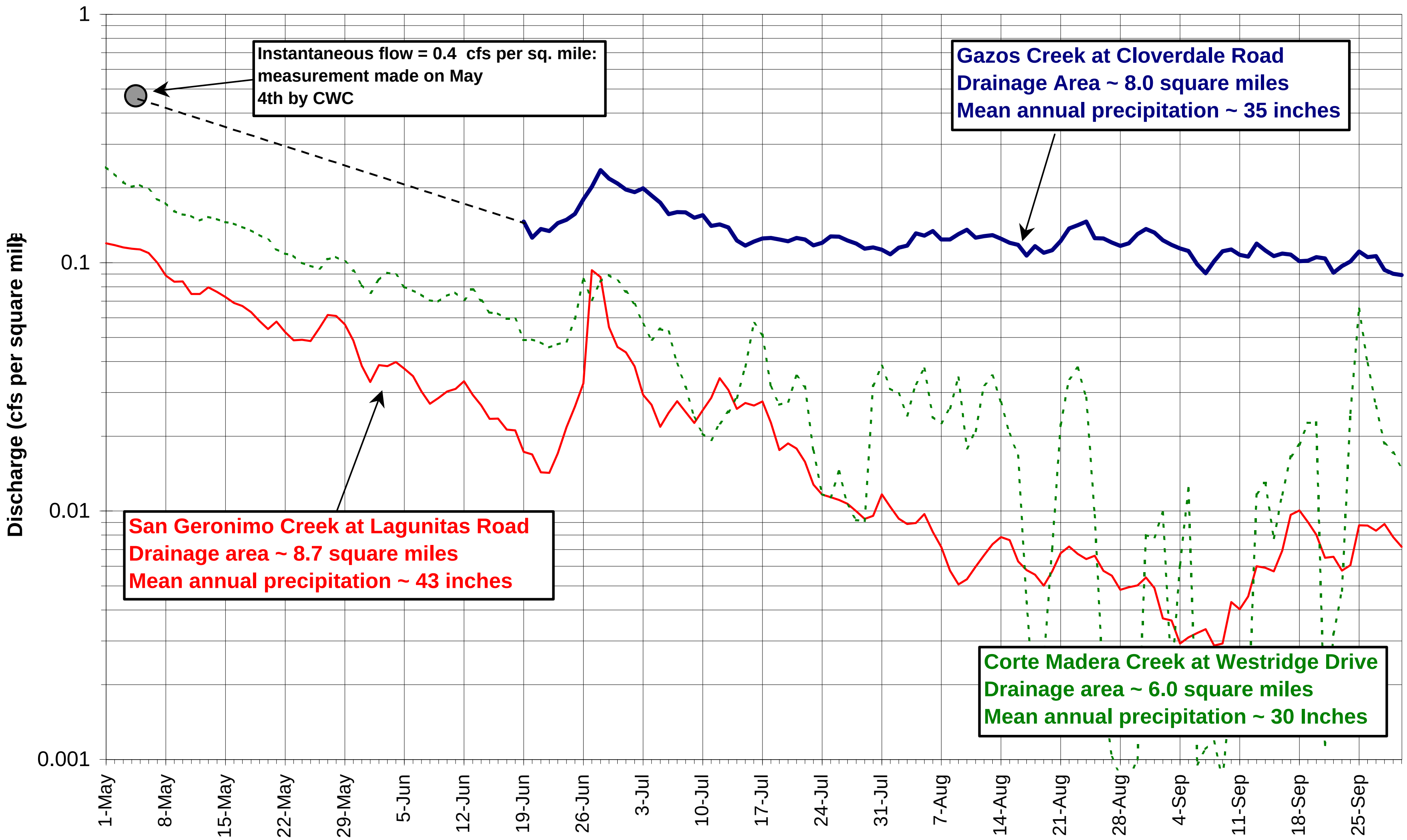

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Figure H-7: Baseflow recession curves in watersheds of similar size: Gazos Creek at Cloverdale Road (heavy line), San Geronimo Creek at Lagunitas Road (light line) and Corte Madera Creek at Westridge Drive in Portola Valley (dashed line), May 1st through September 30, 2001, San Mateo, Marin and San Mateo Counties respectively, California. Rates of baseflow have been adjusted for watershed area.

200022_WY01_GCCR_Q,CRGZ_CM_LG_Baseflow_01

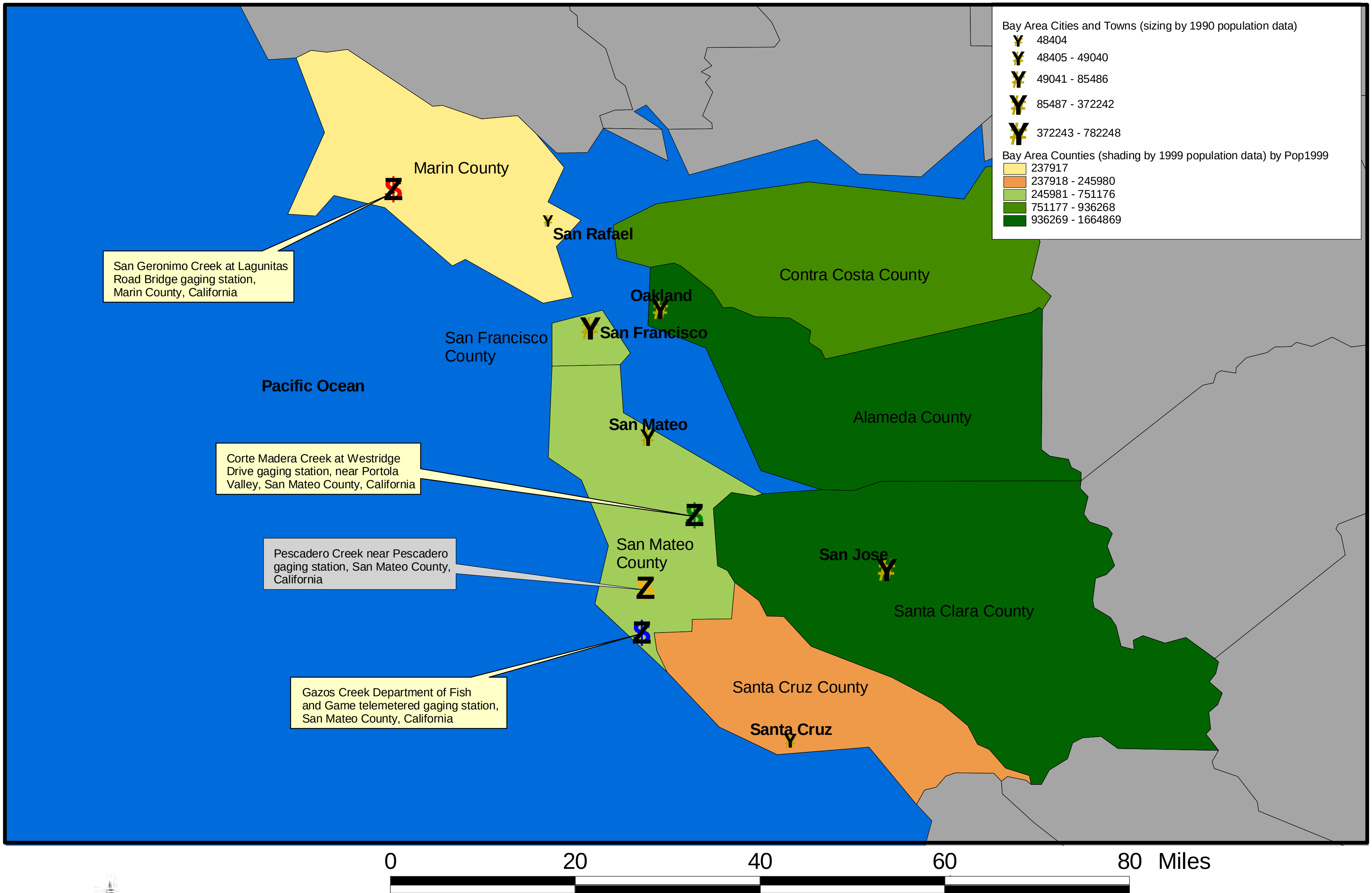

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Figure H-8 San Francisco Bay area regional county map, California. Gaging stations located in regional streams used in the hydrologic analysis are noted.

directly compared. When comparing rates of spring baseflow recession, it is common to use the period starting May 1 and ending June 30th of the given year-the period from June 30 onward is used to describe baseflows. We can make a comparison of rates of baseflow recession for water year 2002 for the Gazos Creek Department of Fish and Game gage and Corte Madera Creek at Westridge Drive gage (**Figure H-9**).

Baseflow recorded at GCDFG in water year 2002 receded at a slightly greater average rate than baseflow recorded at Corte Madera at Westridge Drive, however in general the rates are similar. Data illustrated in **Figure H-9** indicate that for the period May 1 through June 30 of 2002, baseflow recorded at GCDFG recessed at an average daily rate of 0.0040 cfs per square mile while at Corte Madera at Westridge Drive baseflows recessed at an average daily rate of 0.0028 cfs per square mile. **Figure H-9** also illustrates that rates of baseflow recorded in water year 2002 at the GCDFG gage were again greater than rates recorded on Corte Madera Creek at Westridge Drive. For water year 2002, rates of baseflow at GCDFG varied from 1.1 to 15 times greater than rates recorded on Corte Madera Creek at Westridge Drive.

It is important to note that both years plotted in **Figures H-7** (water year 2001) and **H-9** (water year 2002) were average rainfall years; we do not have complete data to describe how the watershed responds during wet or dry years.

H.3.3 Geologic influence on baseflows

Relatively high summer baseflows, persistence of baseflows during droughts, and favorable water quality are attributable in large measure to geologic conditions in the Gazos Creek watershed.

Persistence of summer baseflows in Gazos Creek may reflect presence of three geologic units which have higher aquifer storage than the very low rates typical of the Santa Cruz Mountains, in general:

- **Santa Cruz mudstone**: This brittle unit stores ground water in an extensive fracture system which affects all portions of this formation, as well as very large bedrock landslides with high storage in their slide masses. Both factors are volumetrically significant. The function of the fractures in the Santa Cruz mudstone are perhaps best illustrated by the response of springs and streams draining this unit to the

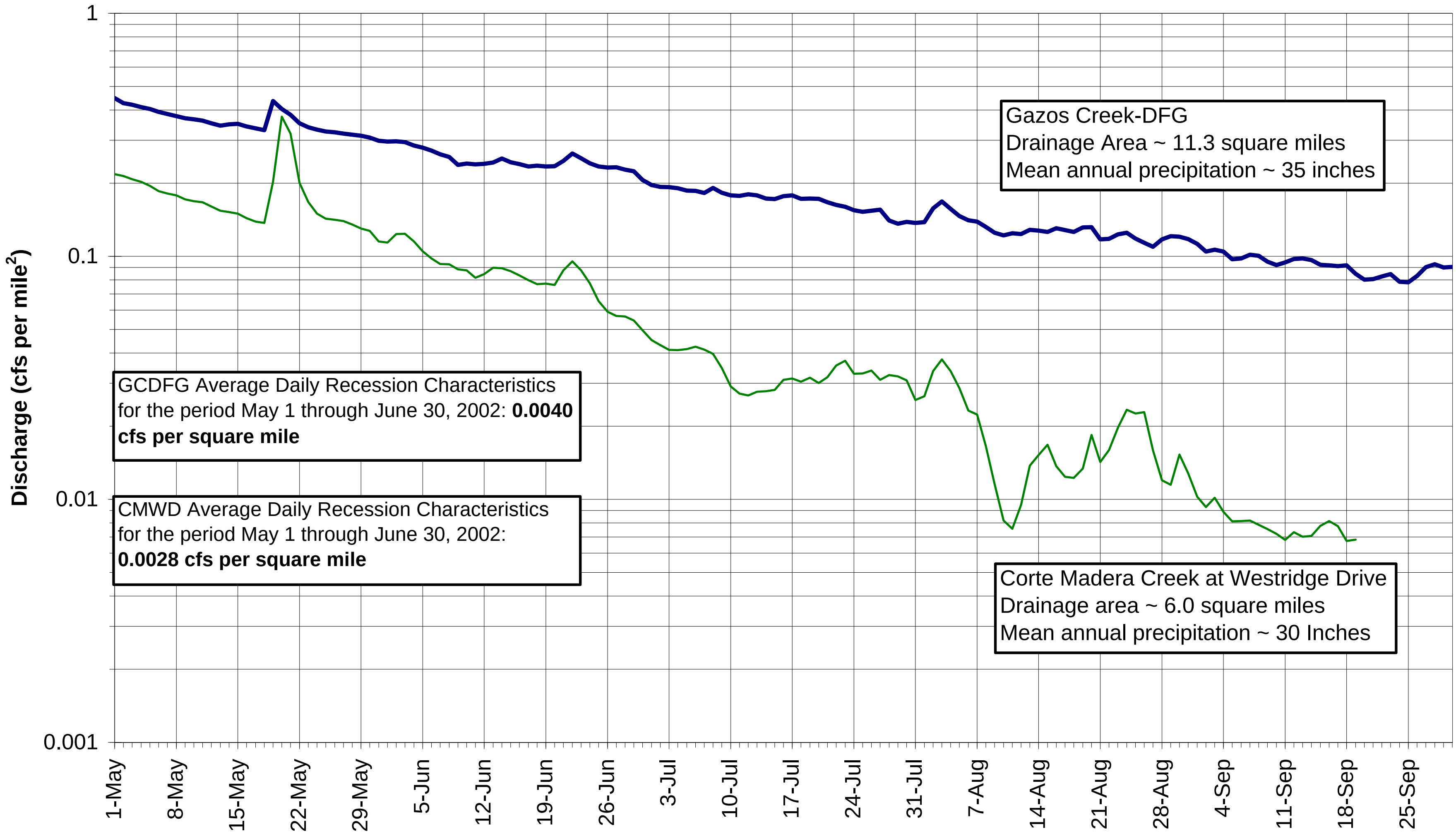

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Figure H-9: Baseflow recession curves for the Gazos Creek Department of Fish and Game telemetered gage (heavy line) and Corte Madera Creek at Westridge Drive (light line), May 1st through September 30, 2002. Rates of baseflow recorded at GCDFG in water year 2002 varied from 1.1 to 15 times greater than those recorded at CMWD for the same period but recessed at slightly greater rates.

200022_WY01_GCCR_Q,GZ_CM_Baseflow_02

Loma Prieta earthquake of 1989, following which 20- to 50-fold increases in baseflow were reported in Waddell and Whitehouse Creeks, (Briggs, 1994; Balance Hydrologics, unpubl.); while flow in other streams also markedly increased (Rojstacer and others, 1992), the increases in the mudstone watersheds are notable for their magnitude and for their distance from the epicenter. The Santa Cruz mudstone tends to form deep and large (~100 acre) rotational landslides that often sustain spring flow near their bases, an indication that the slide masses are retaining and yielding considerable volumes of water (c.f., Hecht and Rusmore, eds., 1973). Several of the largest mudstone-origin landslides in the region are located in the middle reaches of Gazos Creek, the headwaters of Slate Creek, and the north branch of Bear Gulch (South Fork).

- **Santa Margarita sandstone**: Elsewhere in the Santa Cruz Mountains, this unit is an aquifer of regional significance, but has a relatively small area of outcrop and stratigraphic thickness in the Gazos watershed. Still, it is worth noting that baseflows per unit area in the Middle Fork – its largest area of outcrop -- are two or more times larger than in Bear Gulch. The lower member(s) of the Santa Cruz mudstone include sandy interbeds very similar to the Santa Margarita that may also be a secondary factor in sustaining baseflows in the Pine Mountain and Mt. McAbee portions of the Waddell watershed, immediately to the east (Hecht, in prep.), an influence which may extend into the Gazos watershed, and may be factor for baseflows in Bear Gulch and Slate Creek.

- **Vaqueros and San Lorenzo formations**: These formations, which yield very little baseflow to other streams in the Santa Cruz Mountains, especially during the latter half of the dry season (c.f. Ricker and others, 1977; Hecht, 1974). The upper portion of the Vaqueros formation is often distinguished as the Lambert shale, which also tends to yield minimal flows during summer. They are important to baseflows in Gazos Creek simply by their absence. Gazos Creek is the only large watershed of the central Santa Cruz Mountains in which these units do not outcrop (McLaughlin and others, 1989).

- **Butano formation:** Yields to summer baseflow from Butano outcrop areas tend to be quite variable spatially; they are almost always much lower than those from the Santa Margarita sandstone and Santa Cruz mudstone, but higher than those from the large areas of Vaqueros and San Lorenzo formations. We note that much of the

North Fork of Gazos Creek is underlain by materials mapped as Butano formation, but we did not have access to this area and are not in a position to assess whether the higher baseflows emanating from this fork are from the Butano or other units which also outcrop in this subwatershed.

Other important influences which may sustain relatively high summer flows as well as high quality summer flows in Gazos Creek are (1) proportionately lower rates of diversion from the middle and upstream portions of the watershed, (2) land uses consistent with baseflow persistence, and (3) land uses which tend to not adversely affect low-flow water quality.

H.4 Hydrologic Assessment Conclusions and Data Gaps

H.4.1 Hydrologic assessment conclusions

1. Preliminary results suggest that the magnitudes of baseflows originating out of each the North, Middle and South Forks of Gazos Creek is variable likely at the daily level. Results from the limited dataset suggest that baseflows originating out of the North Fork could account for between ~ 50% and ~90% of flows originating out of the upper watershed. More data is needed to better describe baseflow sources and magnitudes of those sources.

2. Baseflows in Gazos Creek are relatively high compared to other regional streams of similar size and annual precipitation.

3. Flows in Gazos Creek are relatively cool and fresh.

4. Baseflow recession rates seem similar to rates for other regional streams

5. Baseflow has been historically persistent in Gazos Creek during times of drought. During the 1st year of the 1976-77 drought, baseflow was persistent in Gazos Creek near to the current GCDFG gage location.

6. Bankfull discharge for Gazos Creek at the DFG gage is roughly 840 cfs

7. Relative magnitude of historic peak flows for the past 50 years is uncertain (i.e. for peaks from water years 1956, 1982 and 1998). However, from high water marks preserved along the creek, we know that: the peak flow from 1982 was higher than the peak flow from 1998, estimates for these peak events are 4,800 cfs and 3,000 cfs, respectively

H.4.2 Hydrologic assessment data gaps

There are two principal data gaps for the hydrologic assessment of Gazos Creek:

1. Current records of winter flow for Gazos Creek are limited to one water year of data. The current records of winter flow in the watershed are limited to water year 2002 with 2002 characterized regionally as normal, in terms of precipitation. This lack of historic data obviously impacts our ability to characterize the history of peak flows in the watershed over the last 50 to 60 years which in turn makes it difficult to characterize various recurrence interval floods-widely used hydrologic measures when comparing and characterizing watersheds. We were lucky in water year 2002 to have recorded the stage associated with the 'bankfull' flow at the GCDFG gage, otherwise the level of certainty associated with any estimate would be greatly reduced.

2. Baseflow in Old Woman's Creek was measured only once in conjunction with this assessment; therefore the relative contribution of baseflow (also storm flow) which originates in this sub-basin is for the most part unknown. Additional measurements of baseflow volumes and dissolved solids (or specific conductance) in the three forks, Slate Creek and Old Womans Creek are needed to establish a more robust baseline of current conditions and to better plan where enhancement measures or structures might be sited. Information is needed especially for summers of wet, dry and multiple-consecutive-dry years.

   Baseflows measured in the upper watershed tributaries (North, Middle and South Forks) as a part of this assessment are limited to just two days of synoptic measurements. These two dates were August 3rd and September 14th, 2001 with the August 3rd measurements representing a more complete picture than the September 14th measurements. See Section A.2.2 of this report for a discussion of these measurements. A baseflow source database, nonetheless, has been assembled as part of this project and provides some insight to baseflow sources and can furthermore serve as a starting point to build from in future years.

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APPENDIX H-A:

Excerpts from: Entrix, 1998, Gazos Creek phase 1 restoration workplan and biological assessment, consulting report prepared for the County of San Mateo in cooperation with Balance Hydrologics, multi-paged

Historic records of spot discharge measurements in Gazos Creek, 1971-1993, San Mateo County, California. The data is given in three different tables labeled H-A-1, H-A-2 and H-A-3.

Table H-A-1

Table 1: *Year-to-year variability in Gazos Creek flows*[1]

Location	*Date Time*	*By*	*Flow (cfs)*	*Water /Air T (°F)*	*Remarks*
Mile 0.4 (first turnout)	11/23/71 1120	Conger	1.32	49/-	Standard Gurley meter
75 ft u/s Campbell diversion	8/10/76 1430	Cogger/Curtis	0.34	59/66	Extreme drought
As above	11/24/76 1500	K.Anderson	0.55	50/59	Drought conditions
25 ft d/s of Muzzi diversion	8/4/78 1415	Gacoka, Torres	1.17	58/58	Mod wet year Muzzi pumps operating
100 ft u/s Campbell diversion	9/27/79 1400	Paulsen	0.96	59/71	Both pumps operating 0.19 cfs d/s pumps
Mile 0.8	9/5/80 1300	Eimoto	1.59	56/59	May be slight overestimate
Old Woman Cr. near mouth	4/9/86 @1100	Hecht	2.0	57/-	Spec. Cond. = 595µmhos/cm@25°C
Just upstream Old Woman Cr.	4/9/86 1115	Hecht	1.78	58/-	Sp.Cond=455µmhos/cm@25°C Wet year
"1.8 mi by road d/s Cloverdale Rd"	6/25/86 1100	Strate	2.18	58/63	Location unclear relative to diversions
"Just downstream of diversion.- 1/2 (mi.) u/s from mouth	6/26/86 0925	Strate	1.94	58/62	Wet year No notes re pumping

[1] Most of these data points were collected by Mr. Robert Zatkin, as part of an ongoing compilation of official records for streams in coastal San Mateo County being conducted by the Committee for Green Foothills through a grant funded by the Packard Foundation.

Table H-A-2

Table 2: *Seasonal variability in flows, Gazos Creek below Muzzi diversion, near mouth*

Date	*Flow (cfs)*
Jan. 10, 1978	42.9
Jan. 23, 1978	38.3
Jan. 31, 1978	15.0
March 20, 1978	20.4
May 2, 1978	18.3
May 11, 1978	11.7
May 18, 1978	7.3
May 25, 1978	5.8
June 8, 1978	3.9
Aug. 4, 1978	1.17 (pumps operating)
Sept. 7, 1978	0.2 (pumps operating)

Table H-A-3

Table 3: *Seasonal variability in flows, Gazos Creek at stream miles 0.3 and 2.7.*

Date	*Flow (cfs) mile 0.3*	*Flow (cfs) mile 2.7*
April 28, 1993	5.86	
May 6, 1993	5.28	4.46
May 15, 1993	3.85	4.30
May 20, 1993	4.40	4.20
May 26, 1993	5.30	4.90
June 2, 1993	4.07	4.52
June 18, 1993	4.12	4.10
June 29, 1993	3.28	3.59
July 1, 1993	2.97	3.56
July 8, 1993	4.40	3.56
July 23, 1993	4.11	3.47
August 5, 1993	0.37	
August 10, 1993	0.32	
August 23, 1993	0.25	
September 5, 1993	0.37	
September 17, 1993	0.40	
September 23, 1993	0.68	
October 1, 1993	2.59	3.20
October 8, 1993	2.92	3.13
October 14, 1993	2.66	1.26
October 26, 1993	2.78	1.90
November 1, 1993	2.87	2.44
November 7, 1993	3.10	2.72
November 13, 1993	3.17	2.83

APPENDIX H-B:

Creating a Record of Flow

Creating a record of flow

Flow measurements are made with conventional ‘pygmy’ or Type AA (‘standard’) bucket-wheel current meters, with factory calibration, consistent with practices of the Department of Interior agencies and the California State Water Resources Control Board.

At continuous-record stations, water level is measured by pressure-transducers and recorded on electronic “dataloggers” every 15 minutes. The stage record corresponds to the staff plate reading observations, and is derived by a calibrated datalogger and pressure-transducer record of water levels. Transducers are calibrated prior to installation, as well as with every field observation. Specific-conductance probes are pre- and post-calibrated with standard KCl solutions prepared by a state-certified laboratory.

A stage-to-discharge relationship (or ‘rating curve’) is developed for the station; the rating curve is based on our periodic site visits, staff plate readings, and flow measurements. The rating curve is then applied to the stage record to compute the mean flow for each 15-minute period. The 96 individual periods during each day, beginning at midnight, are averaged to compute the mean flow for the day.

APPENDIX H-C:

Estimation of Peak Flows

Estimation of Peak Flows

Balance staff calculated peak flows (corresponding to the past twenty years) and a morphologic bankfull for the Gazos Creek-DFG telemetered gaging station. The peak and bankfull flows were calculated in a five-step process, each step is elaborated further below:

1. Measurement of cross-sectional geometry through the GCDFG gage with a surveyor's level and identification of relevant morphologic features such as top of bank (bankfull) and high-water marks (from 1982 and 1998), in January 2002.

2. The cross-sectional area corresponding to the morphologic bankfull, and high- water marks from 1982 and 1998 through the gage are calculated,

3. Calculation of the gage height associated with the morphologic bankfull, and high-water levels from 1982 and 1998,

4. Calculation of average flow velocities corresponding to cross-sectional areas for the morphologic bankfull, and high-water marks from 1982 and 1998 with a site regression equation relating flow area to average flow velocity, and

5. Using the measured morphologic bankfull flow area and the corresponding calculated average flow velocity to calculate our estimate of bankfull discharge (and discharge associated with high-water marks from 1982 and 1998).

The first step involved measuring cross-sectional geometry of the channel through the Gazos Creek-DFG telemetered gage. During level surveying of the channel geometry, important surfaces and elevations such as the morphologic bankfull and the base of the staff plate were recorded. The morphologic bankfull elevation was determined in the field visually with the aid of a high-water mark left by the peak flow of December 2, 2001. The high-water mark was situated at a distinct break in bank slope that was interpreted as the morphologic bankfull elevation. Other streams in the region also likely experienced a bankfull flow on December 2nd of 2001. Other high-water marks located in the transect were believed to be remnants of peak flows from 1982 and 1998 based on the age of trees growing near the high-water marks and the documented relative magnitude of winter flows in regional watersheds over the past twenty years.

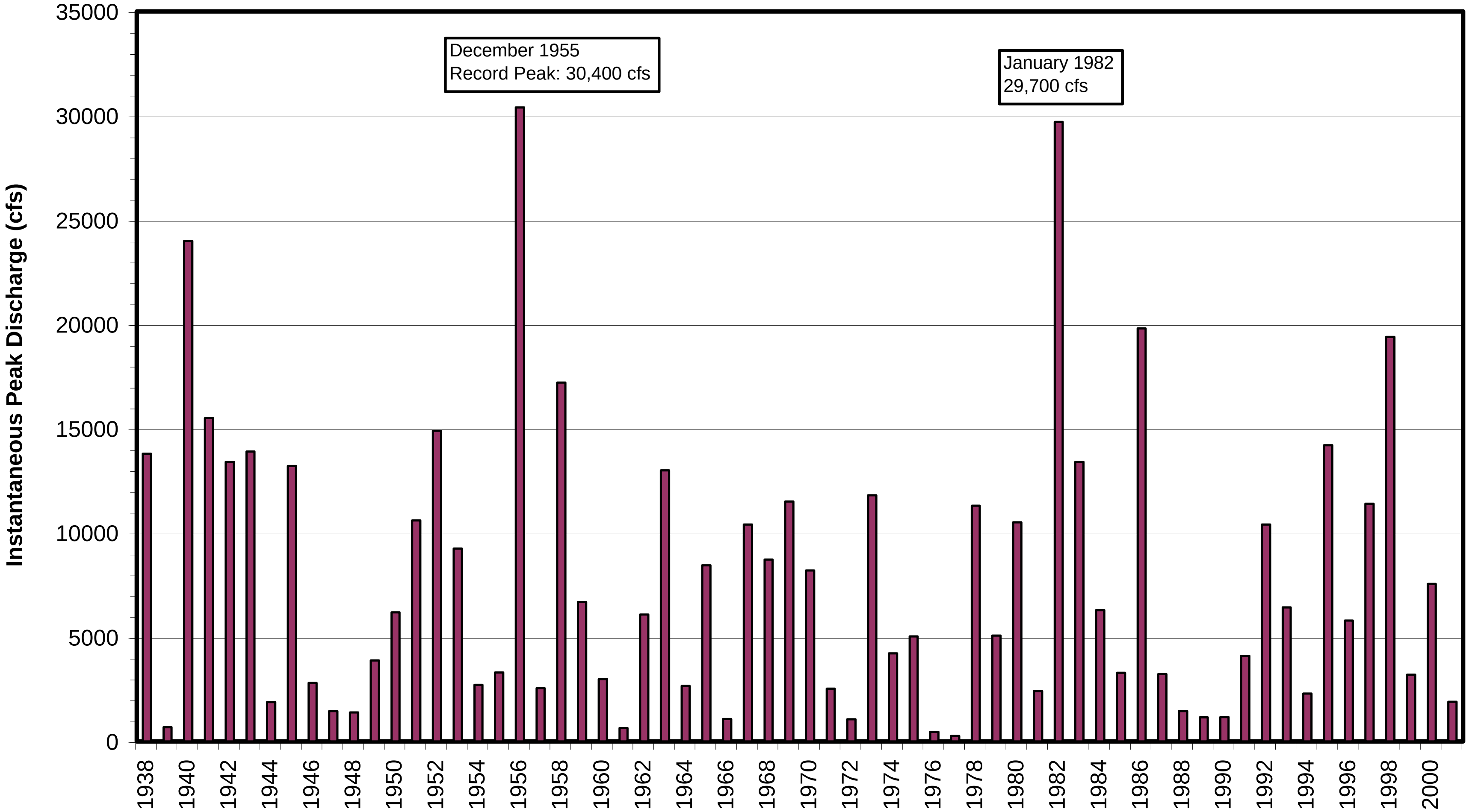
In the second step, cross-sectional areas corresponding to (1) the morphologic bankfull elevation (2) the 1998 high-water mark and (3) the 1982 high-water marks were calculated for the channel at the telemetered gage. The cross-sectional level survey at the gage enabled calculation of the gage height associated with the morphologic bankfull as well as the 1998 and 1982 high-water marks relative elevations. The surveyed high-water marks for 2002 agreed with the stage recorded by our datalogger. The various calculated gage heights were used in the third step where it was substituted into a regression relationship for observed gage heights and measured average velocities at the telemetered gage. This step generated an estimated average flow velocity corresponding to the morphologic bankfull gage height and gage heights associated with peak flows in 1998 and 1982.

Cross-sectional flow area and average velocity values were then substituted into the continuity equation for the calculation of flow:

$$Q = A * V_{avg.} \tag{1}$$

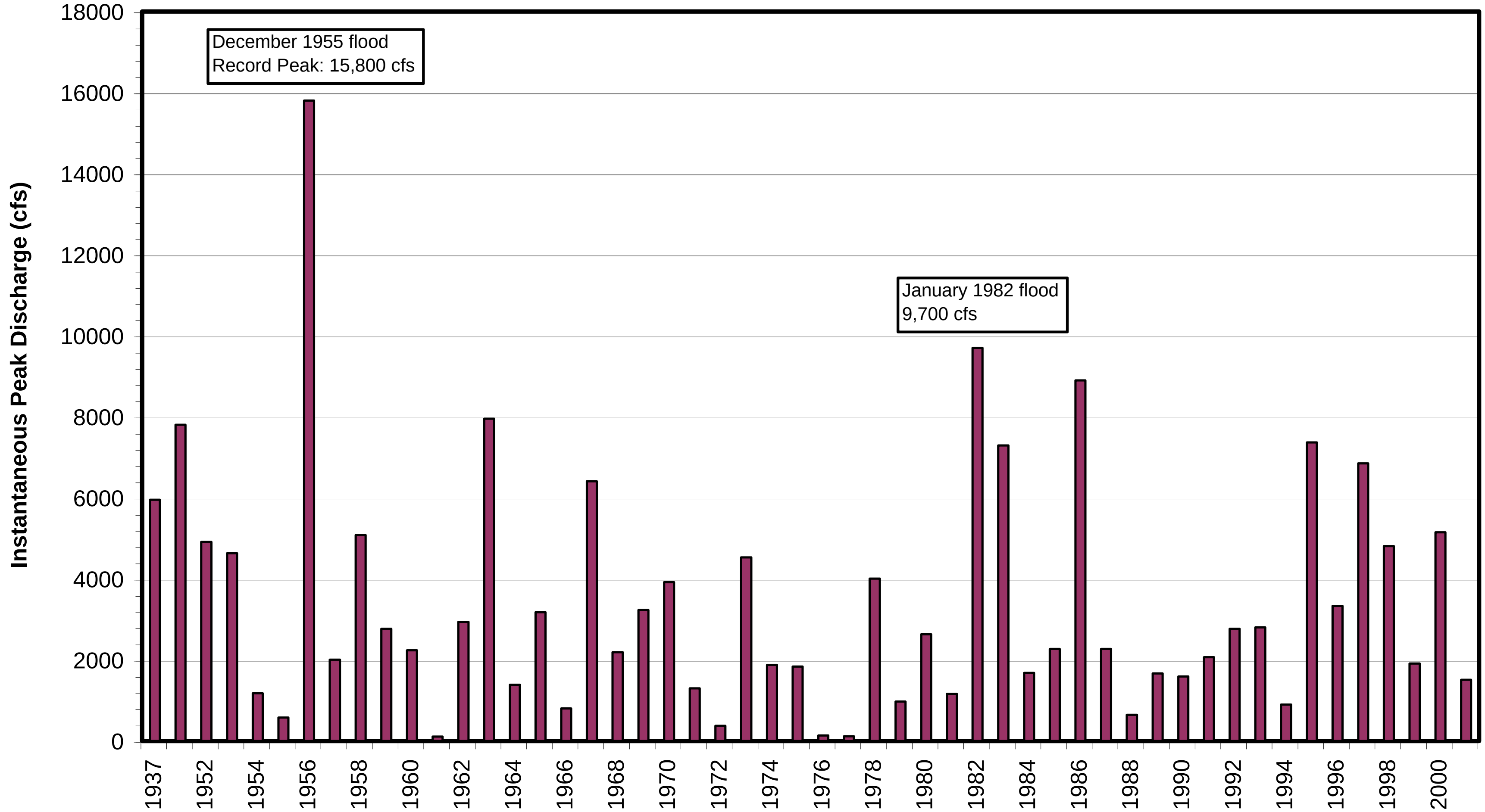
APPENDIX H-D:

Records of annual, instantaneous peak streamflows for San Lorenzo River at Big Trees and Soquel Creek at Soquel, Santa Cruz County, California. The data is illustrated in two different figures labeled H-D-1 and H-D-2.



Balance Hydrologics, Inc.

Figure H-D-1: Record of annual instantaneous peak streamflows for the San Lorenzo River as reported by the USGS for San Lorenzo River at Big Trees, I.D. 11160500, water years 1937 through 2001, Santa Cruz County, California. The San Lorenzo River gage is located roughly 35 miles southeast of Gazos Creek and has a drainage area at the gage of about 106 miles^2, but much of its watershed lies a few miles east of Gazos Creek's, and is affected by similar storms. In the San Lorenzo Basin since water year 1938, 1956 and 1982 have recorded the largest annual instantaneous peak streamflows.



Balance Hydrologics, Inc.

Figure H-D-2: Record of annual instantaneous peak streamflows for Soquel Creek as reported by the USGS for Soquel Creek at Soquel, I.D. 11160000, water years 1937, 1951 through 2001, Santa Cruz County, California. Soquel Creek is located roughly 40 miles southeast of Gazos Creek and has a drainage area at the gage of roughly 40 miles^2. The largest annual instantaneous peak streamflows were recorded in December 1955 and January 1982.

APPENDIX H-S:

Gazos Creek Department of Fish and Game telemetered gage water year 2002 data report: streamflow and sediment discharge.

Source: Owens, J.O., Shaw, D.S., and Hecht, B., 2002 (draft), Annual hydrologic record and sediment yield for Gazos Creek above Highway 1, San Mateo County, California: data report for water year 2002, consulting report prepared for the California Department of Fish and Game, multi-paged.

Foreword

This report titled “Annual Hydrologic Record and Sediment Yield for Gazos Creek above Highway 1, San Mateo County, California: Data Report for Water Year 2002” (Gaging Report) is being included as an appendix in the Gazos Creek Watershed Assessment (GCWA) for several reasons, even though it is written and will be also be released as a separate, stand-alone data report.

1) The GCWA draws integrally upon much of the information in the Gaging Report, so the related observations, data, and analyses should be available to all GCWA readers

2) The sediment-discharge measurements and analyses for Gazos Creek are developed as part of the Gaging Report, because it is logically linked to the streamflow analyses and based in part upon them, but the data need to be available to GCWA readers.

3) The two projects, while funded separately, were both supported by the California Department of Fish and Game, and both projects were managed by the Coastal Watershed Council. The California Coastal Conservancy also funded the Gazos Creek Watershed Assessment and (with the Department and Game) will likely be supporting the enhancement program which will implement recommended measures.

4) The Gaging Report serves, in part, as a baseline to assess future changes in the watershed -- most especially the efficacy of measures to protect baseflows and to reduce sediment transport and sedimentation. As such, it is integral to monitoring the enhancement program and (to the extent discernible) other changes in the watershed.

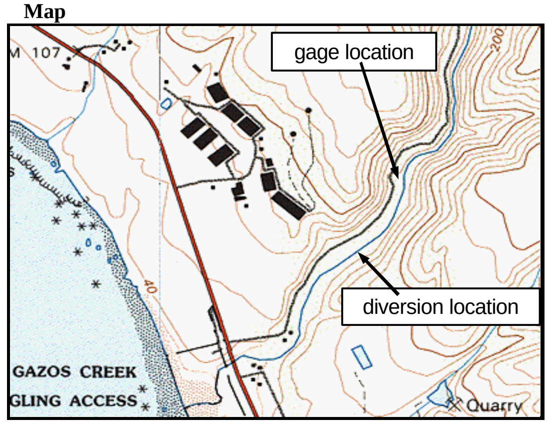
The Gaging Report will also be available as a separate, stand-alone report under its own cover, with editorial differences, but identical data.

ANNUAL SUMMARY FORMS

Water Year:	2002
Stream:	Gazos Creek
Station:	above Highway 1
County:	San Mateo, CA

Form 1. Annual Hydrologic Record

Map



Station Location / Watershed Descriptors

Latitude: 37 10' 17", Longitude: 122 21' 18". Gage is located on north side of creek, about 0.5 miles upstream of Highway 1. Land use includes mainly forested open space, some forestry activities, and a few low-density residences. Drainage area upstream of gage is 11.3 square miles.

Mean Annual Flow

Mean annual flow (MAF) for WY 2002 was 12.0 cubic feet per second (cfs).
For comparison purposes, rainfall in WY 2002 was fairly close to average annual precipitation.

Peak Flows

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
11/12/2001	11:00	1.86	61	12/21/2001	5:15	2.94	133
11/29/2001	2:30	4.17	410	12/22/2001	13:15	2.86	124
12/2/2001	8:45	6.27	933	12/31/2001	4:00	2.58	93
12/14/2001	3:15	2.46	79	1/2/2002	12:15	4.83	481

Peak for Period of Record (Oct. 2 to Sept. 30, 2002): 933 cfs on Dec. 2, 2001.

Period of Record

Staff plate installed February 2001, water-level recorder installed 10/2/01. Gaging funded by Department of Fish and Game, California Coastal Salmon Recovery Program.

WY 2002 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	0.87	1.27	45.77	52.44	9.93	10.80	8.66	5.05	3.35	2.22	1.56	1.27
2	0.87	1.17	392.28	304.31	9.56	10.11	8.33	4.83	3.36	2.18	1.78	1.18
3	0.96	1.16	115.25	160.86	9.14	9.54	8.09	4.76	3.33	2.18	1.90	1.20
4	0.99	1.13	66.45	90.92	8.78	9.16	7.99	4.65	3.23	2.16	1.77	1.18
5	1.00	1.09	45.04	62.97	8.47	8.86	7.75	4.56	3.17	2.11	1.66	1.10
6	0.98	1.04	34.81	50.62	8.18	11.05	7.62	4.44	3.08	2.10	1.59	1.11
7	1.00	1.07	29.25	42.07	12.20	15.61	7.47	4.35	2.97	2.06	1.57	1.15
8	0.94	1.07	25.76	36.29	20.86	14.32	7.23	4.26	2.90	2.16	1.49	1.14
9	0.99	1.07	24.58	31.73	14.91	12.06	7.13	4.18	2.69	2.06	1.41	1.07
10	0.97	2.03	22.20	28.18	12.79	15.16	7.13	4.14	2.72	2.01	1.38	1.04
11	0.94	5.76	20.31	25.00	11.53	13.42	6.81	4.08	2.70	2.01	1.41	1.07
12	0.91	22.45	18.73	22.85	10.80	12.33	6.60	3.99	2.71	2.04	1.39	1.10
13	0.86	5.82	17.63	21.16	10.20	11.52	6.21	3.90	2.75	2.01	1.45	1.11
14	0.85	3.13	38.95	19.69	9.70	10.90	6.25	3.94	2.85	1.96	1.44	1.09
15	0.86	2.49	25.14	18.49	9.15	10.37	6.04	3.96	2.76	1.94	1.42	1.04
16	0.90	2.15	21.16	17.43	10.14	9.86	5.94	3.87	2.71	2.00	1.47	1.04
17	0.91	1.96	25.93	16.44	17.45	13.03	6.40	3.80	2.64	2.01	1.45	1.03
18	0.94	1.79	24.19	15.28	13.63	11.09	5.73	3.73	2.67	1.95	1.43	1.04
19	0.96	1.70	23.80	14.45	16.56	10.00	5.58	4.93	2.65	1.95	1.49	0.96
20	0.89	1.68	66.26	13.72	25.52	9.51	5.52	4.57	2.65	1.95	1.49	0.91
21	0.87	1.73	97.99	13.32	22.33	9.06	5.47	4.32	2.79	1.89	1.33	0.91
22	0.87	2.45	76.93	12.59	19.41	10.56	5.20	3.99	2.99	1.84	1.33	0.93
23	0.88	1.91	66.21	11.78	17.33	14.16	5.23	3.84	2.86	1.81	1.39	0.96
24	0.86	9.20	47.04	11.22	15.73	14.05	5.26	3.76	2.73	1.75	1.41	0.89
25	0.81	5.82	35.91	10.89	14.44	12.95	5.19	3.69	2.65	1.72	1.34	0.88
26	0.82	3.78	29.88	12.81	13.29	12.04	5.15	3.66	2.62	1.74	1.28	0.94
27	0.86	2.97	25.38	11.90	12.36	11.19	5.18	3.62	2.63	1.76	1.24	1.02
28	0.88	10.45	27.90	13.05	11.58	10.24	4.90	3.57	2.57	1.59	1.33	1.05
29	0.86	123.48	34.82	12.04		9.74	4.95	3.54	2.53	1.54	1.37	1.02
30	2.54	22.90	47.68	10.99		9.40	5.00	3.48	2.33	1.56	1.36	1.02
31	1.87		73.28	10.40		8.77		3.37		1.55	1.33	
MEAN	0.99	8.19	53.11	37.93	13.43	11.32	6.33	4.09	2.82	1.93	1.46	1.05
MAX. DAY	2.54	123.48	392.28	304.31	25.52	15.61	8.66	5.05	3.36	2.22	1.90	1.27
MIN. DAY	0.81	1.04	17.63	10.40	8.18	8.77	4.90	3.37	2.33	1.54	1.24	0.88
cfs days	30.72	245.71	1646.52	1175.89	375.98	350.83	190.00	126.83	84.57	59.79	45.27	31.43
ac-ft	60.93	487.36	3265.87	2332.38	745.76	695.88	376.87	251.56	167.74	118.60	89.79	62.35

Monitor's Comments

1. Continuous water-level record for all days starting 10/2/02; flow for 10/1/01 assumed to be the same as 10/2/01.
2. Multiple stage shifts were applied to the rating equation. Stage shifts adjust for local scour and fill in addition to water-level changes due to algae growth, or leaf and debris jams.
3. A large log and debris jam formed on or about Dec. 2, 2001. Adjustments to the record were made to account for the backwater effects associated with the log jam.
4. Peak values were estimated by using a surveyed stream cross section and high-water marks.
5. Values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.

Water Year 2002 Totals:		
Mean annual flow	**12.0**	(cfs)
Max. daily flow	**392**	(cfs)
Min. daily flow	**0.81**	(cfs)
Annual total	**4364**	(cfs-days)
Annual total	**8655**	(ac-ft)

Water Year:	2002
Stream:	Gazos Creek
Station:	0.5 miles upstream from mouth
County:	San Mateo County, CA

Form 2. Annual Sediment-Discharge Record

WY 2002 Daily Suspended-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	Qss Annual
1	0.0	0.0	68.2	29.2	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	1875.6	1260.6	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	282.4	499.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	61.8	160.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	18.7	50.7	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	8.6	26.2	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	5.0	15.0	0.7	0.9	0.1	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	3.4	9.6	2.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	3.0	6.4	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	2.2	4.5	0.4	0.7	0.1	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.1	1.7	3.1	0.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
12	0.0	7.3	1.3	2.4	0.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.1	1.1	1.9	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	15.7	1.5	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	3.2	1.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	1.9	1.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	3.8	0.9	1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	2.8	0.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	3.1	0.6	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	82.3	0.5	3.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	200.2	0.5	2.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	105.4	0.4	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	60.0	0.3	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.3	21.3	0.3	0.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	9.4	0.3	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	5.4	0.4	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	3.3	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	15.9	4.6	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0	365.2	8.9	0.4		0.2	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	2.7	31.3	0.3		0.2	0.0	0.0	0.0	0.0	0.0	0.0	
31	0.0		83.2	0.2		0.1		0.0		0.0	0.0		
TOTAL	0	392	2979	2079	19	10	2	0	0	0	0	0	**5,481**
Max.day	0	365	1876	1261	3	1	0	0	0	0	0	0	**1,876**

WY 2002 Daily Bedload-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	Qbed Annual
1	0.0	0.0	81.7	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	1373.0	1045.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	346.6	563.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	54.0	192.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	10.8	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	3.8	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	1.8	7.9	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	1.1	4.4	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.9	2.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.6	1.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.4	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
12	0.0	4.5	0.3	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	10.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	1.4	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	0.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	1.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	89.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	244.7	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	114.7	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	51.3	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.1	12.8	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	4.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	2.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	1.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	18.4	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0	331.8	4.0	0.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.9	26.6	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	
31	0.0		80.5	0.0		0.0		0.0		0.0	0.0		
TOTAL	0	356	2523	1899	5	2	0	0	0	0	0	0	**4,784**
Max.day	0	332	1373	1046	1	0	0	0	0	0	0	0	**1,373**

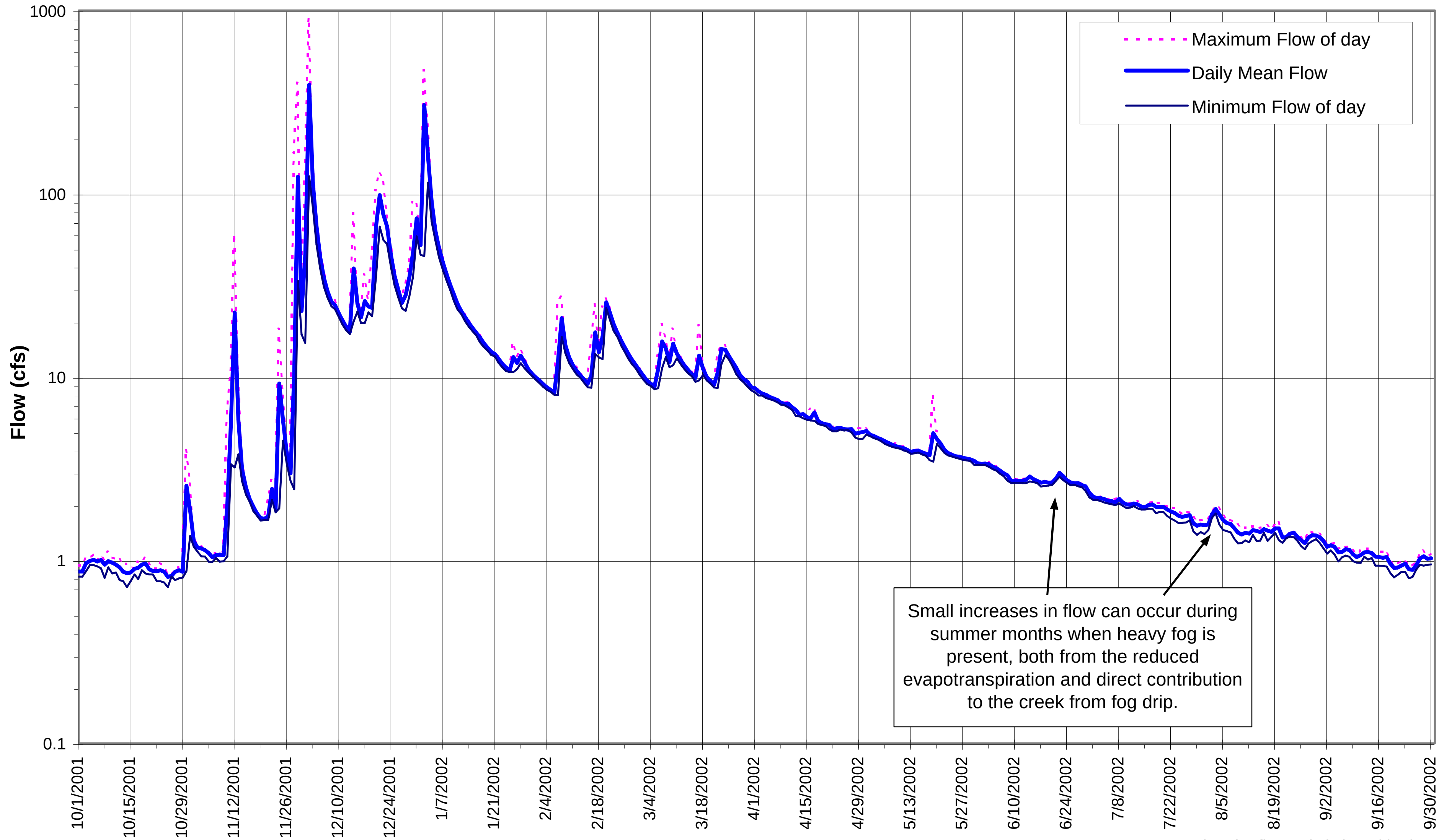
Daily values are based on calculations of sediment discharge at 15-minute intervals.
Multiple sediment-discharge rating curves were used for different periods of the year and ranges of flow.
Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.

Total annual sediment discharge (suspended- plus bedload-sediment discharge)
WY 2002: 10,265 ***tons***

Balance Hydrologics, Inc. 900 Modoc Street, Berkeley, CA 94707 (510) 527-0727; fax: (510) 527-8532

TABLES

FIGURES



Note that the flow axis is logarithmic.

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Figure 1. Daily flow hydrograph: Gazos Creek above Highway 1, water year 2002. One characteristic of Gazos Creek is high sustained baseflow through the dry season compared to many other creeks of similar watershed size. A significant point of diversion is a about 400 yards downstream from this station, but flow at this location does not appear to be affected.

Gaging sponsored by the Department of Fish and Game, California Coastal Salmon Recovery Program

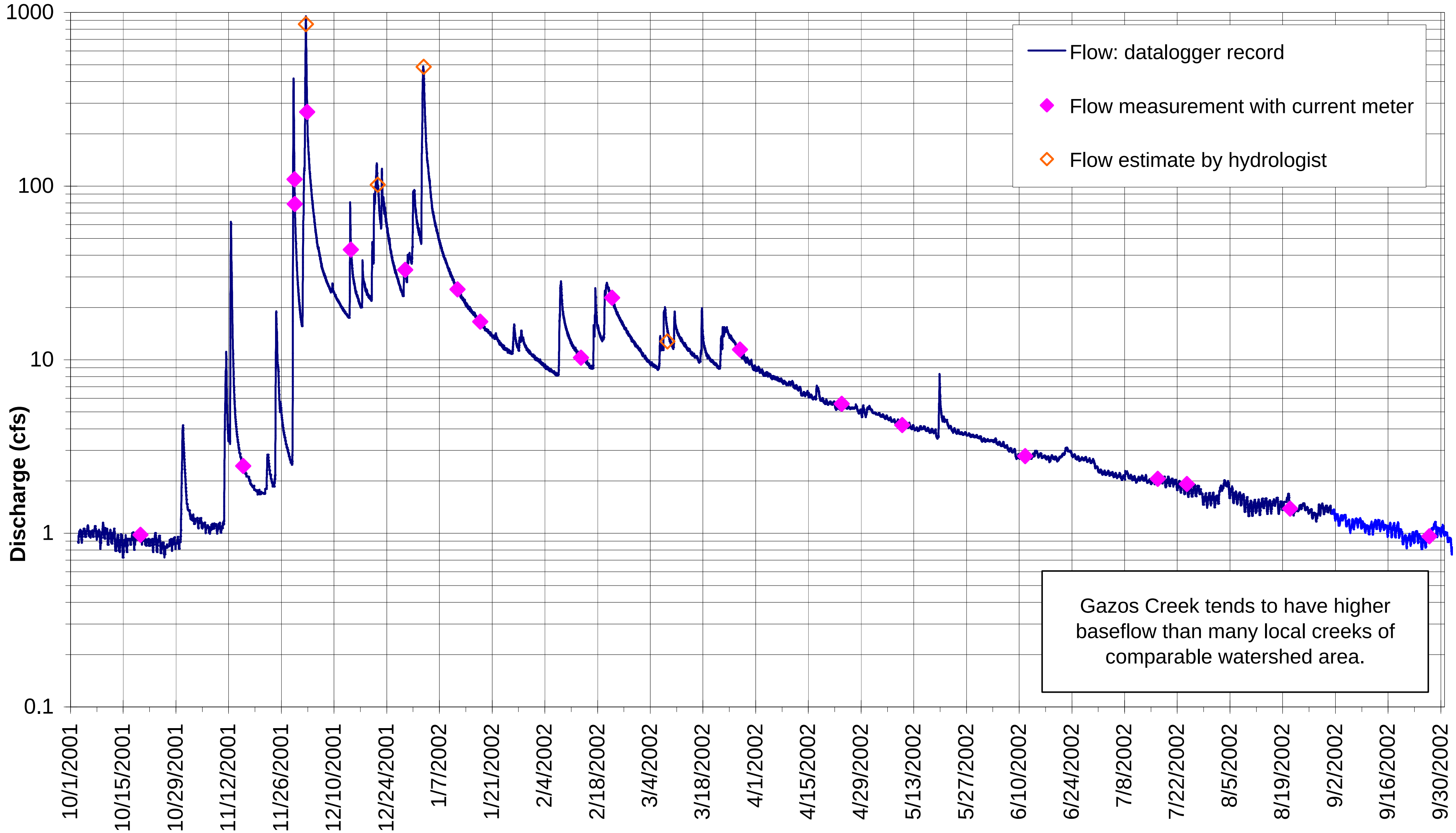

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Figure 2. Streamflow hydrograph (15-minute data): Gazos Creek above Highway 1, water year 2002. We estimated the two largest peak flows of the water year with the use of our surveyed cross-section profile and high-water marks.

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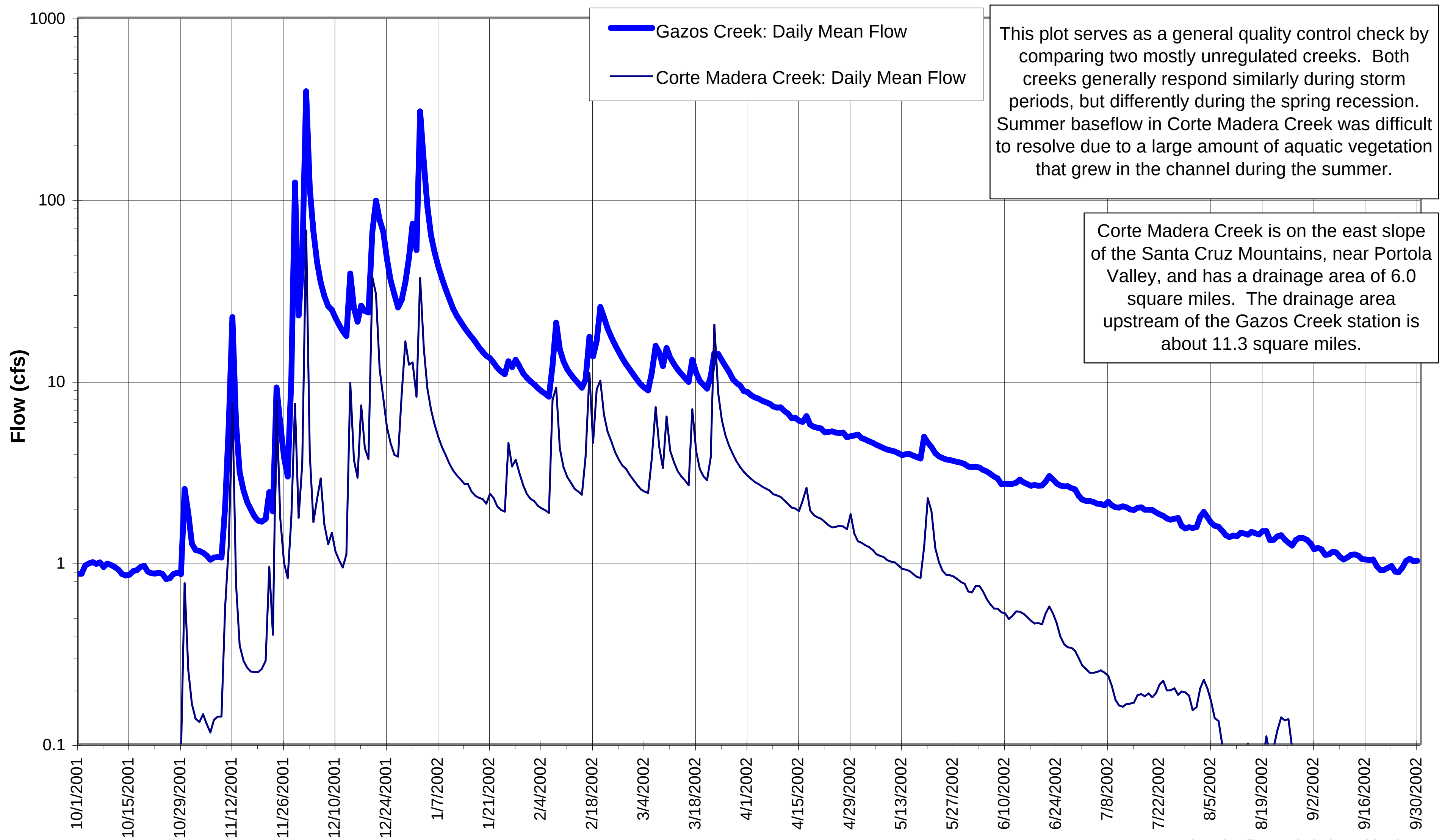

Note that the flow axis is logarithmic.

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Figure 3. Daily flow hydrographs: Gazos and Corte Madera Creeks, water year 2002.
The timing of each flow peaks coincides; Gazos has more flow total; Corte Madera Creek is flashier (higher peaks compared to baseflow). Gazos Creek has higher and more sustained baseflow through the dry season.

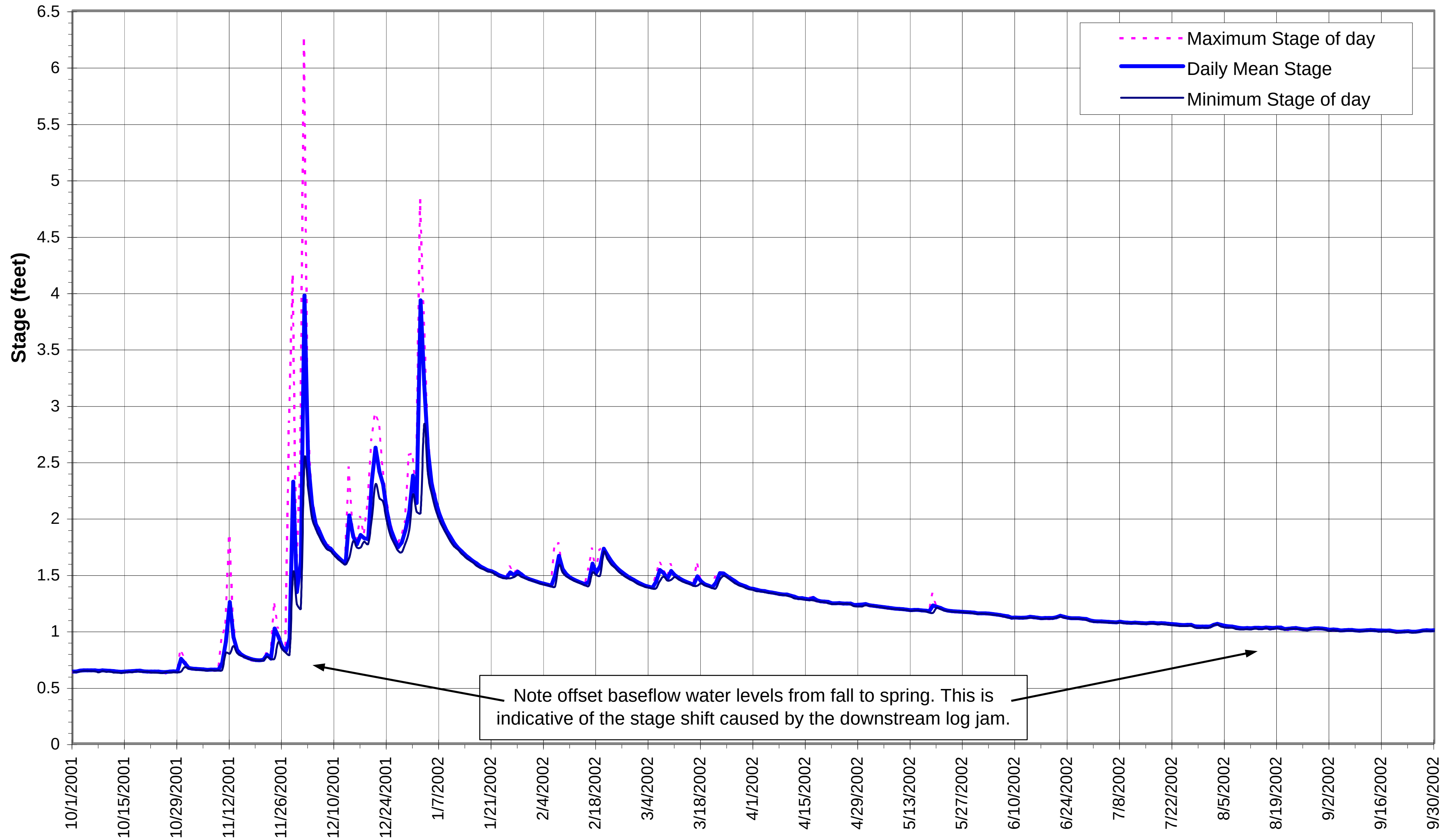

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Figure 4. Daily stage hydrograph: Gazos Creek above Highway 1, water year 2002. The stage record was affected by the log jam that formed about 100 feet downstream from the gaging site on or about Dec. 2, 2001.

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Gaging sponsored by the Department of Fish and Game, California Coastal Salmon Recovery Program

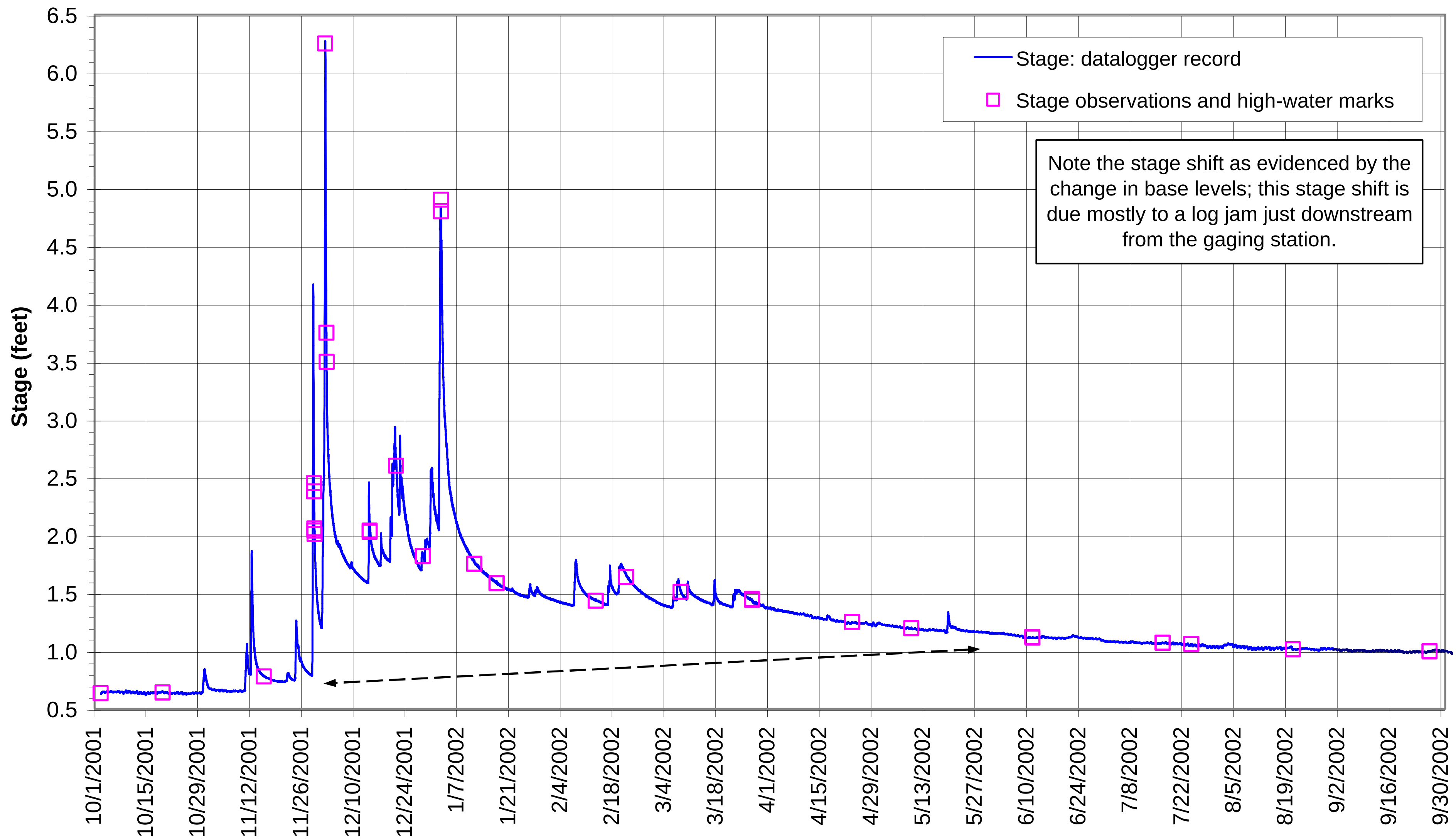

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Figure 5. Stage hydrograph (15-minute data): Gazos Creek upstream of Highway 1, water year 2002. Stage is the water level measured against the staff plate; stage is a relative datum and does not represent the absolute depth of water in the creek. High-water marks match the peaks in the stage record.

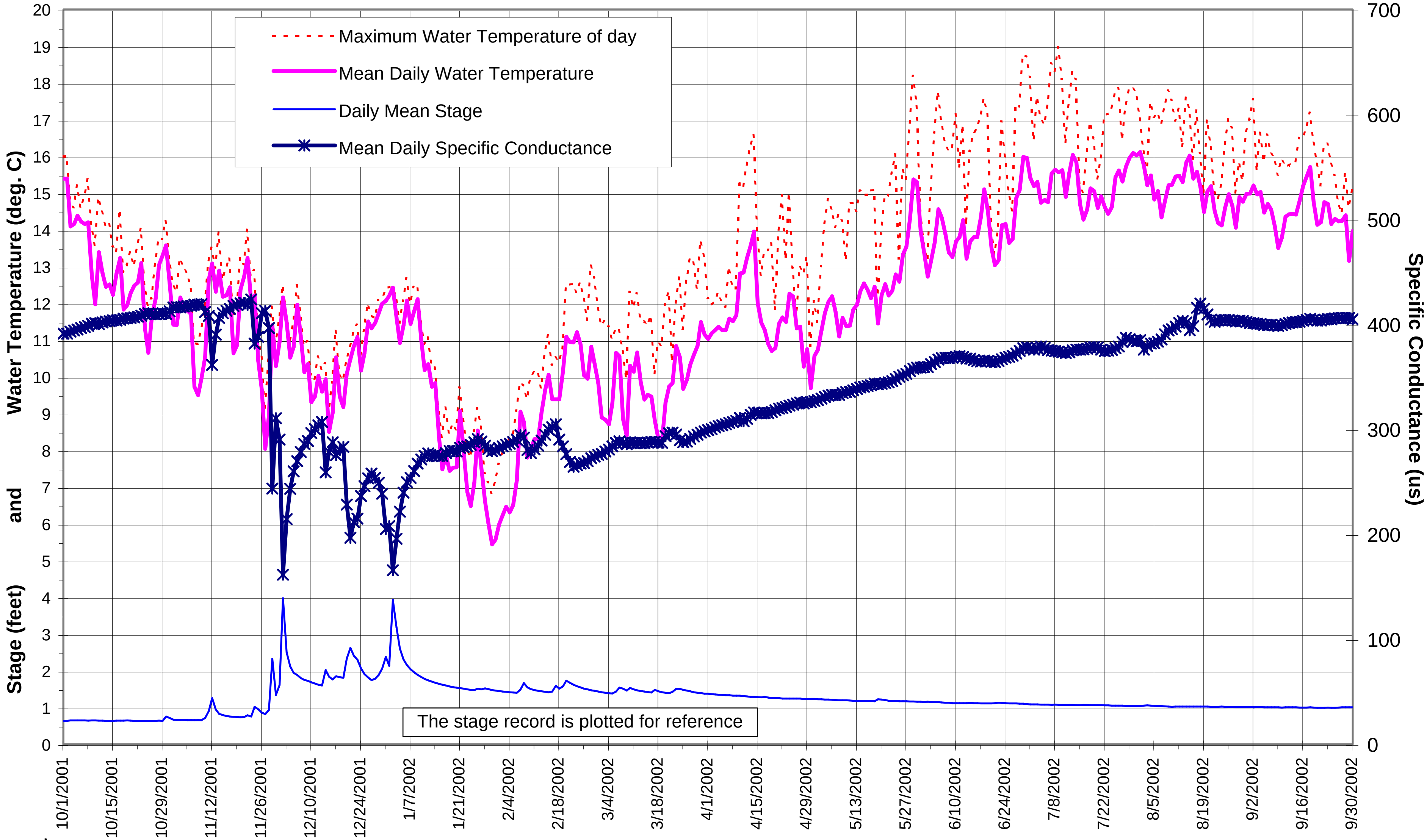

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Figure 6. Daily water temperature and specific conductance: Gazos Creek above Highway 1, water year 2002. Specific conductance is a measure of the amount of dissolved minerals in the water.

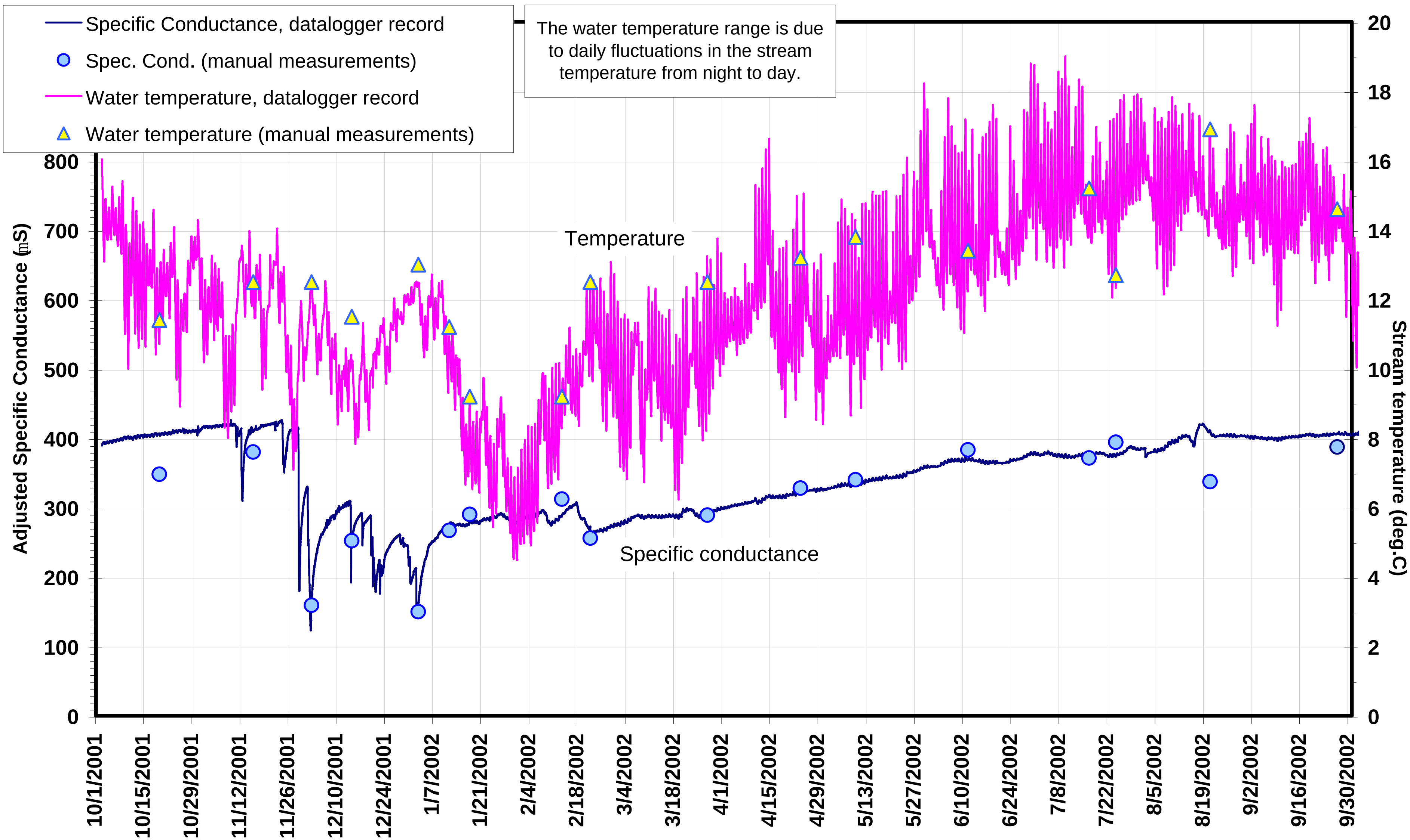

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Figure 7. Specific conductance and temperature: Gazos Creek above Highway 1, water year 2002. Specific conductance in Gazos Creek is lower than many area creeks, and does not respond as much to small rainfall amounts. The maximum water temperatures are among the lowest in the Santa Cruz Mountains.

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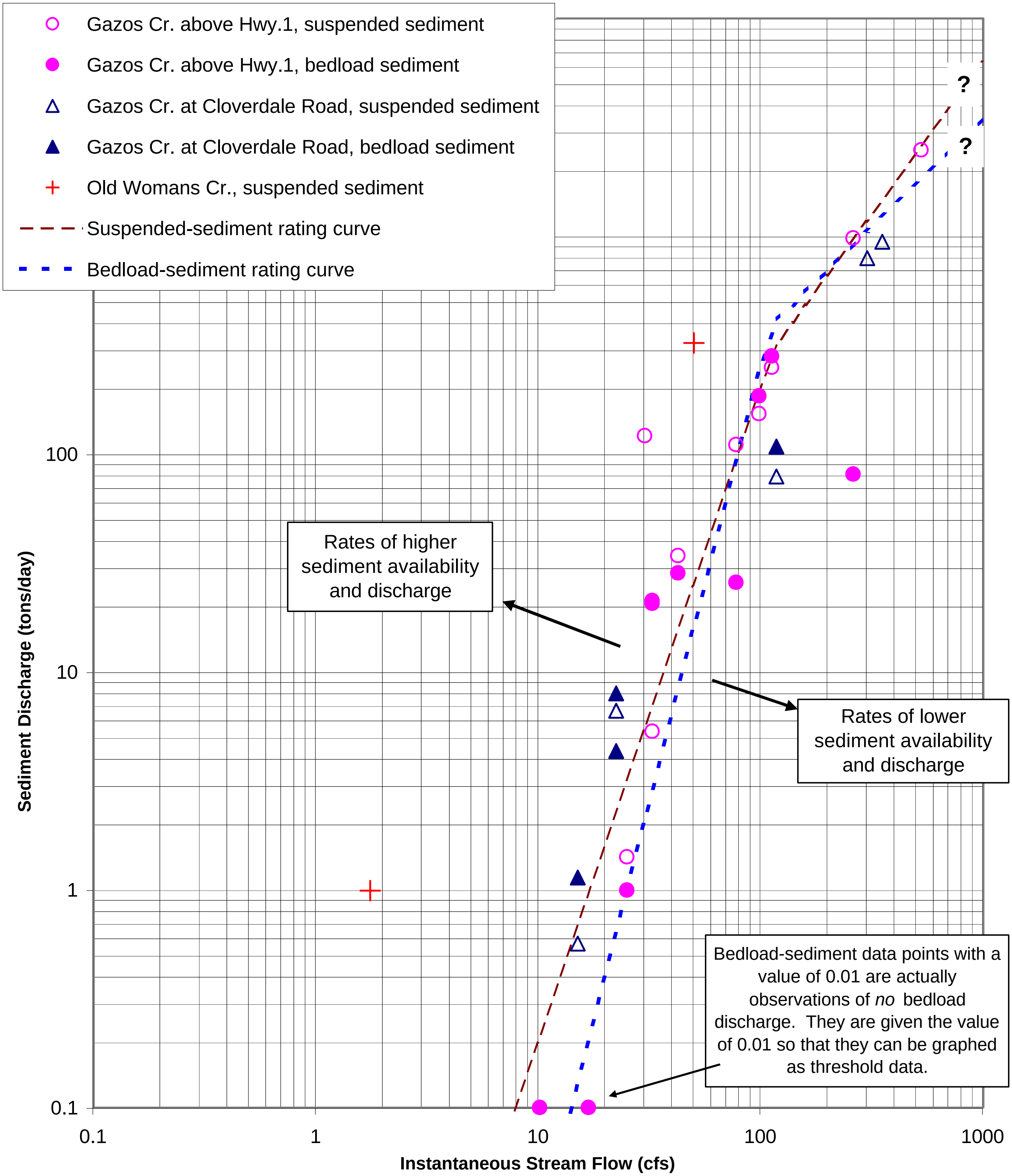

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Figure 8. Measured sediment discharge rates and estimated sediment rating curves: Gazos Creek, water years 2001 and 2002. Note that Old Woman Creek has high suspended-sediment concentrations which influences downstream locations.

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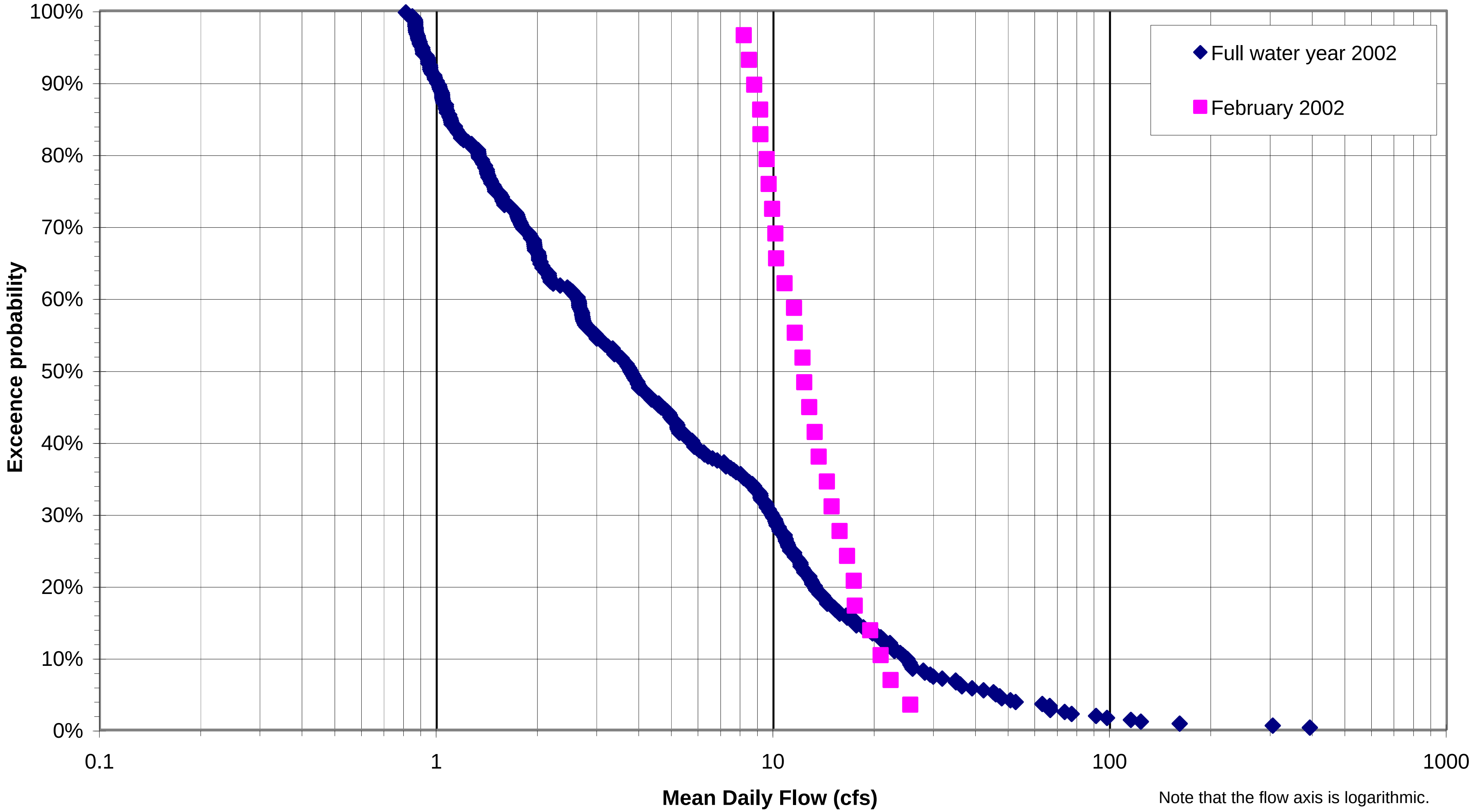

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Figure 9. Daily flow exceedence plot: Gazos Creek above Highway 1, water year 2002.
Flow exceedence is becoming more commonly used in determining recommended diversion levels from creeks.